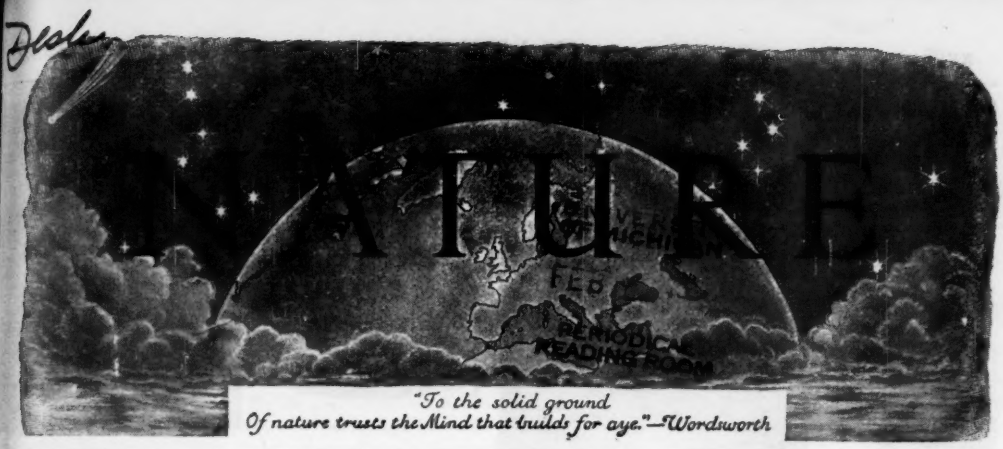

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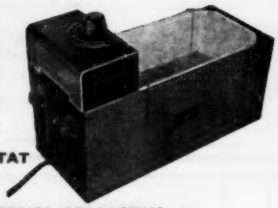

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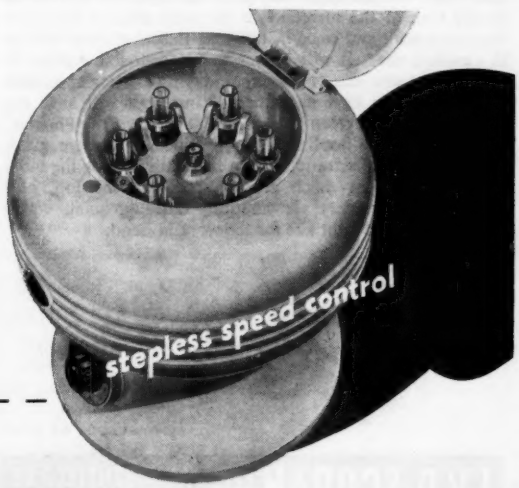

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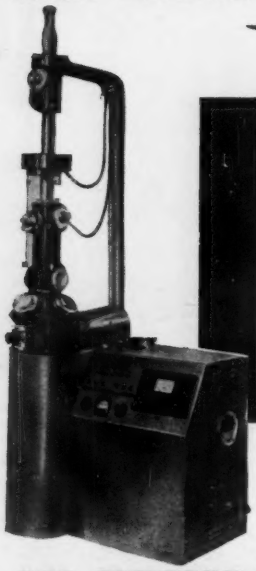

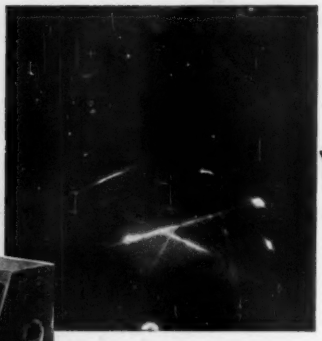

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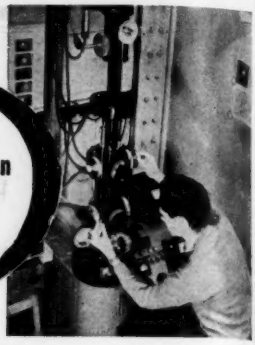

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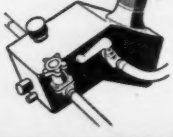

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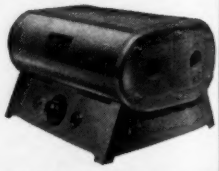

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LEADERSHIP IN LOCAL GOVERNMENT

NEITHER Mr. H. Morrison, in his book "Government and People : a Survey from the Inside", nor the contributors to the symposium on the Civil Service in the current issue of the *Political Quarterly* made more than passing reference to the question of local government in Britain. Mr. Morrison, however, referred specifically to one point which deserves further attention and which, if neglected, may well frustrate all attempts to improve the efficiency of the Civil Service and the smooth functioning of the task of government, namely, the serious effects of over-work on Ministers and the senior Civil servants. He says : "It is a nice point to consider which is the most injurious to the public interest : an overworked Minister or an overworked Civil servant". Mr. Martin Lindsay comments in similar terms in an article entitled "Government by Endurance".

Both are dangerous and undesirable, and sometimes unavoidable, even if a government does not overload itself or the organization by which the task of government is performed. Mr. Morrison's observations here are a sober warning against over-loading the legislative programme at the behest of a political party without regard to the administrative consequences, and by implication they are a salutary reminder of the need in a democracy for leadership and responsibility. Statesmanship, wisdom and judgment are required to translate a political programme into executive action and legislation, and if they are disregarded through political prejudice or passion, trouble is bound to ensue. Indeed, Mr. Morrison concedes that it is probably more dangerous for the higher Civil servants to be over-worked than for Ministers to be over-worked. It is the Civil servants who are responsible for the detailed planning, thinking and drafting, and bad mistakes may be made by them without the Minister being aware of the position.

The Crichel Down episode shows that there is some substance in this, even when mistakes have arisen through bad judgment rather than over-work. If, however, the burden on Ministers and on Civil servants is to be reduced, more attention must be given not merely to the administrative structure of the Civil Service and of the Cabinet system, but also to the functions of Parliament and the way they are performed. It will not be sufficient merely to see that the programme of legislation is reasonably proportioned to the amount of Parliamentary time available and to the demands it makes alike on Ministers and Civil servants. It is essential also to see that, without impairing the essential functions of the House of Commons as the watch-dog over public expenditure and the guardian of individual citizens against official injustice, Parliament is not distracted from its larger duties by demands which could be equally or better met at the regional or local level.

The Government's decision, announced by the Prime Minister on November 18, to accept the proposals of the report of the Royal Commission on Scottish Affairs and to transfer to the Secretary of State for Scotland certain responsibilities in Scotland of the Minister of Transport and Civil Aviation, of the Lord Chancellor and of the Minister of Agriculture and Fisheries is a step in the right direction. The case for local government reform is in fact closely connected with this need for devolution. The importance of Parliament as the great forum of debate on public policy, and the undoubted advantages of centralization in certain technical fields, do not remove the need for vigorous, independent and healthy local government. While it has been necessary from the point of view of the larger public interest to remove such matters as gas and electricity supply, public assistance and health services largely from local government control, the effect on local government should not be regarded without concern. It is essential that the functions of local government should not be thus restricted beyond the minimum that the general interest demands ; all that is possible should be done to preserve the vitality of local government and to encourage the individual citizen not only to take a live interest in it, but also to understand it and use the opportunities it affords of influencing policy in matters that directly concern his way of life.

Apart from this, the functions of local government have become disproportionate to the finances, organization and areas established for their exercise. Frequently, local authorities are either too small to finance the services they provide, or should provide, or too large to manage efficiently the services they finance. Moreover, while Mr. Attlee's Government declined to give the Local Government Boundary Commission which it appointed in 1946 adequate instructions, that Government could neither accept the tentative policy suggested by the Commission nor formulate one of its own. Nor has Sir Winston Churchill's Government either formulated a policy or taken any action.

When Minister of Housing and Local Government, Mr. Harold Macmillan promised to promote any reforms the local authority associations succeeded in agreeing to recommend, and on March 26 expressed a hope that he would present some measure of local government reform during the present Parliament. Meanwhile, the Government has continued the unhappy practice of placing further responsibilities on local government authorities without providing them with the resources to match their responsibilities. It has become manifest that in the matter of national parks, for example, such neglect promises to defeat the whole purpose of the enactment of Parliament ; recently the specific proposal has been canvassed that the National Land Fund should be used for national park purposes, at least to the extent of meeting the cost of preserving amenity. The Peak Park Planning Board, for example, is seeking the support of the National Parks Commission in pressing for legislation to such an end.

Local government opinion is unanimous that financial reform is even more pressing than structural change, and there is no lack of recognition of the importance of remoulding local government so as to revitalize it. The remoteness of some local government services and the uneconomic character of others may well be due less to the fact that many local government areas bear little relation to real communities, than to the failure to distinguish in status, for the basic local government units, between the extremes of the minor district or borough and the major 'all-purpose' county borough. Apart from this, the services which most closely concern the public and where the local touch can contribute most, such as the social and personal services, like education, maternity, child welfare and other preventive health services, and the care of children and the aged, have been removed from the county districts. Where the local aspects of local government are of most importance, local government has virtually ceased to function.

Unless this is corrected, the real vigour of local government and its roots in the community will be endangered, and thereby parliamentary democracy itself. That was one common theme in the addresses which Mr. Attlee and the Archbishop of York delivered at the triennial conference of parish councillors on September 23. Both stressed the value of the small unit in local government, and the dangers attending excessive centralization. Mr. Attlee was concerned lest the increasing size of our local government and national units makes our democracy too remote from the people. Dr. Cyril Garbett urged that in spite of limited statutory powers, the parish councils could create a strong and healthy public opinion in every parish, and that their freedom of discussion and independence constituted real obstacles against the encroachments of central authority.

Mr. Attlee favoured the system of several tiers in local government, rather than bringing such government into the hands of one competent body. This was essentially the solution of the Boundary Commission, which suggested the creation of an intermediate class of 'most-purpose' authority suitable for the bulk of middle-sized and larger towns, irrespective of their present purpose. The 'most-purpose' authority would be large enough for autonomous control of all but the most specialized social services, and would admit extra-local jurisdiction only for impersonal functions requiring wide areas, such as police, fire, ambulance services, public utilities, technical education and major planning work.

What needs to be remembered is that efficiency is not the sole test of local government or the reason for desiring reform. The educational aspect of local government is no less important now than when Mill wrote in the middle of the past century. Indeed, while from the point of view of efficiency, unified administration of large regions is probably more satisfactory than that of a single county was formerly, the educational function of local government is of increasing importance, and any reform of local government should be as much concerned to promote that function as to secure efficient administration. If local government is in fact to provide the means by which local groups can manage their own affairs and feel that they can influence effectively some of the policies that determine their daily welfare, and at the same time provide the training ground for those wishing to enter public life, local government must not only be local: it must retain and develop functions sufficiently important for it to attract the services of people interested in public affairs. It must offer, for example, to the technical or professional man the opportunity of contributing something as a citizen to the course of public affairs.

Unfortunately, this aspect appears largely to be overlooked in the proposals for reform which have hitherto been canvassed, and the difficulty of obtaining unprejudiced candidates of high quality for local government is also seriously increased by the growing tendency to bring party politics into local government and even into technical questions. The Association of Municipal Corporations has reaffirmed its devotion to the one-tier form of local authority (the all-purpose county borough), condemned the proposals for the reorganization of local government issued by associations of county, urban and rural district and parish councils, and asked the Minister of Housing and Local Government to prepare a plan of his own. There appears to be no hope of agreement between the various associations as to the one-tier or two-tier, let alone the three-tier systems; but that breakdown does at least avert the danger of a compromise which would disregard the public need and the ultimate purpose of local government. Mr. Harold Macmillan indicated in March that the Government had already done a lot of preliminary work, and the fact that the dispute over local government cuts right across party lines gives his successor, Mr. Duncan Sandys, more scope for manœuvre.

Mr. Sandys promised on November 16 to make a statement shortly about the Government's intentions, and he indicated in reply to a further question that if legislation was proposed there would be a White Paper. It would appear, in fact, that the Minister now proposes to do what the boroughs have urged: to set down in a White Paper the broad principles which the Government has made up its mind to follow, and the discussions which he is having with representatives of local authorities will enable him to recommend a definite course to be followed. The absence of any reference to local government reform from the Queen's speech on November 30, however, suggests that the Government has no intention of introducing legislation dealing with this question during the present session of Parliament.

Pending Mr. Sandys's promised statement, there is thus no clear evidence that either major political party is prepared to spare the Parliamentary time and to court the unpopularity that is bound to attend the attempt to deal boldly with local government reform. Meanwhile, although all parties and critics agree that the present system is anomalous and inadequate, and although divisions of opinion cut right across party lines, the burden on central government remains; and at the local end interest

dwindles and efficiency diminishes. In such a position it is essential for the public, irrespective of party, to urge on whatever minister may be responsible for local government the vital importance of early and firm action to stimulate the renaissance of effective and democratic local government.

Local authorities, it should be remembered, have the virtues and vices of all representative bodies; they are part of the method by which people govern themselves, and by which those specially qualified can put their knowledge and skill at the service of the community. They encourage and develop responsible citizenship, and their strength is a safeguard against the capture of central government by a would-be dictator. They are in touch, moreover, with the circumstances, feelings and needs of their areas, and efficiency in local government would be dearly bought if it destroyed local variety, initiative and responsiveness, and above all the sense of responsibility of the authority to the local electorate.

The principles which should determine the attitude of the central government towards local government were well set forth by D. N. Chester in his book published three years ago dealing with their financial and administrative relations. Local government cannot retain vitality unless Parliament and Whitehall trust the local authorities, in the absence of very good reasons to the contrary. Minute supervision is incompatible with a sense of responsibility in the supervised: it is also expensive in man-power and wasteful. Moreover, variety in local action and policy has strength and meaning. Variety is a consequence of local independence, of adaptation to differing local views and conditions, and of freedom to experiment; and it is from this point of view that the introduction of party politics into local government may be regretted. We cannot have local self-government with complete uniformity or the rigidity of a party caucus. Nor need all local authorities be treated alike. It is neither good administration nor good democracy to make no discrimination between the varying size and efficiency of existing or future local government units.

Of the possibilities open to Mr. Sandys or his successor as Minister of Housing and Local Government, the solution recommended by the Local Government Boundary Commission probably offers the best prospect of acceptance. The amalgamation of a few counties and the reduction of the number of county boroughs would indeed meet with some objections; but they would be largely discounted by the wide range of functions given to the medium-sized towns and by giving to the counties a few large-scale services. Some form of regional authority would, however, be required to provide for the large conurbations such as London, Birmingham, Manchester, Liverpool, Leeds and Newcastle, which now account for some forty per cent of the whole population, and where such services as main roads, open spaces, fire services and water supply can only be planned on a regional basis. With the welding of minor authorities into units big enough to resume some of their lost powers, such as those in the social services, and yet at the same time small enough to possess the personal touch and the local knowledge which are indispensable in welfare work—and especially in that among old people—such measures offer a reasonable prospect not merely of establishing reasonable relations between local government and the central authority but also in re-invigorating local authority. In this way the attitude of the electorate may be transformed; when local government is able to offer more scope and thus to attract councillors of higher quality, it should have resources adequate for the efficient discharge of its functions, so that it can offer a career with sufficient prospects to attract and retain the services of officers of the highest quality.

THE RESISTANCE TO EVOLUTIONARY CHANGE

Genetic Homeostasis

By Prof. I. Michael Lerner. Pp. vii+134+3 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1954.) 12*s*. 6*d*. net.

THE great advances in evolutionary theories which followed the restatement of the principle of natural selection in Mendelian terms can by now be considered classical. A new phase of progress is, however, already under way, and to this Prof. I. M. Lerner makes a stimulating contribution in his new book.

As he points out, "older evolutionary theories have tended to consider Mendelian populations as relatively uniform, with reserves of variability carried as recessive mutants at individually low frequencies". But more recently "the evidence on concealed variability in natural and domestic populations compels us to view Mendelian populations as being exceedingly heterogeneous aggregates of largely heterozygous genotypes". In fact, we have now come to define the natural sub-units of a widespread species, not in terms of local races of supposedly uniform genetic constitution, but rather as suggested by Dobzhansky, who describes a "Mendelian population" as "a reproductive community of sexual and cross-fertilised individuals which share a common gene pool". This common stock of genes, which is passed around from individual to individual during sexual reproduction, is considered to contain several different allelomorphs at many or most of the possible loci, so that each individual will be multiply heterozygous. Most of the allelomorphs, of course, will produce much slighter developmental effects than those commonly used in laboratory work. If by selection we concentrate the genes acting in a certain direction, and produce a sub-population which differs from the original one by greater development of some character we are interested in (such as a higher milk yield or production of eggs), we almost invariably find that the sub-population has simultaneously become less fit, and would be eliminated by natural selection. It is to this phenomenon that the name 'genetic homeostasis' has been given, implying that if, in a population at equilibrium under natural selection, action is taken (for example, artificial selection) which results in a change in gene frequencies, natural selective processes will be set in motion which tend to restore the gene frequencies to their original value.

The main gist of Lerner's book is a thesis as to the mechanism of these homeostatic processes. One

pillar of his argument is the recognition that the effect which a change of gene frequencies has on the incidence of natural selection will depend on the way the genes affect the development of the individual organisms concerned. It is refreshing to find a population geneticist who realizes that he cannot avoid talking embryology and who does his best to do so in a sophisticated rather than an elementary fashion. Lerner's next step is to point out that, in organisms which have been submitted to natural selection, development is to some extent canalized or 'buffered'; that is, it involves feed-back mechanisms of such a kind that the normal optimum adult form tends to be produced under a fairly wide range of conditions. Then follows the really new point which he is making. He argues that this buffering is dependent on heterozygosity, and that when we select for a particular character and thus produce a sub-population with changed gene frequencies, the concomitant lowering of fitness arises because the selection inevitably produces a greater degree of homozygosity, which renders the individuals of the population more at the mercy of chance circumstances during their growth.

There is a certain amount of evidence from several different organisms that cross-bred, heterozygous individuals are better buffered in their development than inbred, relatively homozygous ones; and again, there is some evidence, though not very much, that the more efficient buffering is associated with a greater fitness in the face of natural selection. The evidence does not, however, all tend in one direction; for example, hybrids between local races of *Drosophila* from widely separate localities are less fit than cross-bred individuals from a single population, though they might well be expected to be more heterozygous. It seems probable, indeed, that we have to think of any one natural population as possessing what Dobzhansky has called a "co-adapted gene complex"; that is, a collection of particular allelomorphs which have been selected because they interact together to give rise to well-buffered development. The most far-reaching arguments in Lerner's book, however, rather discount the importance of the specific nature of the genes which are heterozygous or homozygous. He safeguards himself at various places by stating that the particular character of the genes concerned is, of course, of importance; but he devotes a large part of his exposition to urging that the efficiency of developmental buffering (and therefore the fitness) may depend on the degree of heterozygosity as such, without reference to which loci are heterozygous.

In my view this is throwing the baby (the general principle of the specificity of gene action) out with the bath water (the importance of single major genes as opposed to large numbers of less-effective gene differences). One can, for example, easily obtain populations each of which has its buffering lowered in respect of a particular developmental sequel to a specific environmental stimulus, and one can show that the differences between the populations are genetically determined. Whether this effect on the buffering is due to homozygosity or not, it must at any rate be brought about by specifically different genes in the different populations. Nevertheless, although one feels that Lerner's thesis does not contain the whole truth, it may contain a part of it, and at least point toward some theoretical developments which have not yet been fully worked out. We still understand so little about the mechanisms involved in developmental buffering that one would hesitate to deny that Lerner may be correct in suggesting that there is some non-specific effect of homozygosity on that process, even though one retains the belief that there are also specific effects which he seems to pass over rather too lightly. In any event, one can only be grateful for such a clear and stimulating discussion of topics which are in the very forefront of scientific advance in one of the most fundamental of all biological fields.

C. H. Waddington

ST. MARY'S HOSPITAL MEDICAL SCHOOL

The History of St. Mary's Hospital Medical School
By Sir Zachary Cope. Pp. x+257+26 plates. (London: William Heinemann, Ltd., 1954.) 25*s*. net.

THAT the biography of a medical school reflects, in large part, the history of medical education is well illustrated by the story of St. Mary's Hospital Medical School, which last year celebrated its centenary. The second youngest of the London undergraduate medical schools and a mere babe compared with some of its associates, its trials and tribulations in the past century have to some extent been a common experience; yet it has, as medical schools do, developed its own personality, and some episodes in its history have been unique. It is, for example, the only London medical school which started from a definite plan to build a teaching hospital and medical school at the same time. The Paddington area had developed enormously in the first half of the nineteenth century, due mainly to the Grand Junction Canal with its Paddington wharves and to the building of the Great Western Railway terminus. For this rapidly growing population there was no hospital nearer than St. George's across Hyde Park to the south and the Middlesex Hospital to the east. It happened that, at the time of the project for founding a new hospital, Mr. Samuel Lane was running a successful private medical school near St. George's, but had not achieved an ambition to be appointed on the staff of that Hospital. He and some of his St. George's supporters were elected to the committee charged with building the new hospital, and no doubt it was this group that advocated the founding of a medical school as part of the plan. Indeed, before the hospital could be recognized as a suitable place for clinical instruction of medical students, one of the licensing bodies, the Society of Apothecaries, required that it should have both a resident apothecary and an attached medical school. Accordingly, the building for the new School, accommodating some three hundred students and costing £2,500–£3,000, was completed within four months of its commencement in the summer of 1854. It was an inconspicuous building—"hidden away in the space between the hospital, the Great Western terminus, and the canal, it was as difficult to find as Meckel's ganglion".

As the new Hospital grew in piecemeal fashion, the Medical School took roots under a succession of deans, including Ernest Hart, for many years editor of the *British Medical Journal*; W. B. Cheadle, who persuaded the Hospital to allocate its share of the School profits for the foundation of entrance scholarships and who, with other St. Mary's men, helped to establish the first medical school for women; George Field, who founded a residential college and under

whose attractive personality the School at first flourished but later relapsed into the doldrums; and H. A. Caley, during whose tenure two important appointments were made—B. E. Matthews became School secretary in 1900 and held the post with increasing responsibility and quiet efficiency for nearly fifty years, and Almroth Wright was appointed to the dual lectureship in pathology and bacteriology in 1902, his genius soon imparting a new spirit of enthusiasm to both teaching and research. In the next year, St. Mary's unfortunately lost another brilliant teacher and investigator in Augustus Waller, who for nearly twenty years had taught physiology in the School and was the father of the electrocardiograph. So, after short terms of office by Clayton Greene and Sir John Broadbent, we come to the man whom Sir Zachary Cope rightly calls "the Great Dean"—Dr. Charles Wilson (now Lord Moran), later to become a famous president of the Royal College of Physicians and medical adviser to Sir Winston Churchill, but among St. Mary's men to be remembered always as the architect who over a quarter-century dreamed and planned and brought into being the new St. Mary's Hospital Medical School. After a searing and maturing experience as a regimental medical officer during the First World War, Dr. Wilson was appointed as assistant physician to St. Mary's Hospital in 1919 and became dean in the following year. The outlook for the School at that time was ominous, particularly as the new dean had been told by members of the University Grants Committee that St. Mary's had no future as an undergraduate medical school. But Wilson had great qualities, among them the capacity for quick and determined action. The Royal Commission on Undergraduate Education had lately recommended the establishment of full-time clinical appointments, and although there was no hope of financial support from the University Grants Committee for such a venture at St. Mary's, the dean persuaded two outstanding members of the clinical staff, Dr. Wilfrid Harris and Mr. Clayton Greene, to become part-time directors of new medical and surgical units. This bold step soon had its reward, for the University of London in 1921 agreed to undertake three-quarters of the cost of two clinical units in medicine and surgery, and Dr. F. Langmead and Mr. C. A. Pannett were respectively appointed to be the first full-time professors of medicine and surgery.

The next great problem was to find bigger and better premises. Here again Dr. Wilson so impressed two rich philanthropists, Lord Revelstoke and Lord Beaverbrook, that between them they contributed nearly £90,000 which, with a grant from the University of London, allowed the new Medical School to be opened by King George V in 1933. Another great triumph for the dean was the acquisition of the very fine athletic grounds at Teddington, helped again by the munificence of Lord Beaverbrook. Meanwhile, Dr. Wilson, with his remarkable judgment of character, was steadily improving the quality of the new entrants to the Medical School. By direct contacts with headmasters and college tutors and by personal interviews with the applicants, he was able to attract to the School a steady influx of young men of high intelligence, strong character and athletic ability, so that, in 1934, St. Mary's became the first London School to accept only those students intending to work for a university degree. The social activities of the School also prospered, and by 1945, after twenty-five years tenure of the office of dean, Lord Moran could justly claim that the School had been both materially and spiritually re-created.

This documentary study of a medical school is supplemented by chapters on the development of medical specialization in both pre-clinical and clinical education and on the remarkable story of the band of famous men whom Sir Almroth Wright attracted around him in the Inoculation Department (later re-christened the Wright–Fleming Institute), together with biographical sketches of the School's seven Fellows of the Royal Society and of a galaxy of outstanding men (and one woman) who spent some part of their lives in the service of St. Mary's Hospital and its Medical School. The author, himself associated with the School for more than half a century, will be gratefully acclaimed by a much wider public than the 'old boys' of St. Mary's for this graphic contribution to the history of medical education.

R. CRUICKSHANK

EXPERIMENTAL NUCLEAR PHYSICS

Experimental Nuclear Physics

Edited by E. Segrè. Vol. 1. Contributors: H. Staub, H. Bethe and J. Ashkin, N. F. Ramsey, K. T. Bainbridge. Pp. ix + 789. 120*s*. net. Vol. 2. Contributors: P. Morrison, B. T. Feld. Pp. viii + 600. 96*s*. net. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.)

THE publication of the two-volume review of "Experimental Nuclear Physics", edited by E. Segrè, provides a much-needed summary of development in nuclear physics to take the place of Prof. Hans Bethe's 1937 review of nuclear physics, which at that time rendered a similar service.

The review is provided by a distinguished list of authors. Prof. Hans Staub writes on the development of methods of detecting nuclear particles. The principles and practice of ionization chambers, proportional counters, Geiger–Müller counters, crystal counters, scintillation counters and Čerenkov counters are described as well as cloud chambers or nuclear emulsions. The associated electronic instruments are similarly dealt with and, in particular, fast counting circuits and coincidence circuits. One section is devoted to the detection of neutrons by gaseous detectors, boron trifluoride counters and fission detectors.

Prof. Hans Bethe and Dr. Julius Ashkin write on the passage of radiation through matter. The range–energy relations for protons and alpha-particles are brought up to date and extended out to energies of 3 BeV. when protons have a range of 10 km. This illustrates the great development in the range of particle energies now available to experimental nuclear physics. The range–energy relations are given not only for air but also for hydrogen and different metals. A theoretical discussion of range–energy relation is also given with respect to ionization. The penetration of high-energy electrons and gamma-rays through matter is also dealt with exhaustively.

In his article on nuclear moments and statistics, Prof. Norman Ramsey gives a theoretical discussion on the interaction of the nucleus with atomic and molecular fields, and this is followed by a description of experimental methods of measuring nuclear moments and statistics. The methods of hyperfine structure, band spectra and molecular and atomic beams are well described, and the powerful resonance method for molecular beams is discussed. Microwave

spectroscopy, which has also proved to be a powerful tool, is described. Finally, details are given of all known experimental results on nuclear moments and spins and their regularities, and the significance is discussed. Prof. Ramsey also contributes a section on nuclear two-body problems and elements of nuclear structure. In this section the experimental evidence for the nature of nuclear forces is discussed. Results on proton–proton and proton–neutron scattering are surveyed for energies up to 400 MeV., and an account is given of the theories of scattering and the meson theory of nuclear forces. Finally, the author gives a brief description of the theory of nuclear shell structure.

Prof. K. T. Bainbridge contributes a section on charged particle dynamics and optics, relative isotopic abundances of the elements and atomic masses. The general theory of mass spectrometers is given, including a comprehensive treatment of the different methods of magnetic focusing. Typical mass spectrometers including those of Dempster and Nier and Mattauch are discussed. The section concludes with tables of the relative isotopic abundances of the elements and isotopic masses.

A survey is given by Prof. P. Morrison of the vast amount of experimental work on nuclear reactions which has been carried out during the past decade. The theories of nuclear reactions and their relation to nuclear structure are also thoroughly discussed. A chapter is devoted to nuclear fission and another to nuclear reactions of high energy. Prof. B. T. Feld contributes 380 pages on neutron physics, including a bibliography of sixteen pages. The interaction of neutrons of energy from thermal energies up to many millions of volts is discussed. Experimental techniques of neutron physics are described, and finally the interaction of neutrons with matter in bulk is dealt with, including a chapter on elementary reactor theory.

These two volumes present an encyclopædic survey of the present state of nuclear physics, and should be in the library of all laboratories working on this subject.

J. D. Cockcroft

RADIOISOTOPE TECHNIQUES IN DIAGNOSIS, THERAPY AND RESEARCH

Radioisotope Techniques

Proceedings of the Isotope Techniques Conference, Oxford, July 1951, sponsored by the Atomic Energy Research Establishment. Vol. 1: Medical and Physiological Applications. Pp. vi+466+42 plates. (London: H.M. Stationery Office, 1953.) 50*s*. net.

SINCE the construction of the low-energy experimental pile (GLEEP) and its successor (BEPO) at Harwell, the Atomic Energy Research Establishments at Harwell and at Amersham have supplied radioactive isotopes for clinical and research purposes in Great Britain and in many overseas countries. These Establishments have become, in consequence, informal clearing-houses for problems and ideas relating to the production, manipulation and application of radioactive isotopes. For the steadily increasing number of medical and scientific workers and engineers using radioisotopes, it was therefore highly profitable that senior members of the Establishments should organize a conference on radioisotope techniques in 1951. The conference was held in Oxford and was attended by nearly five hundred representatives of some twenty nations. The proceedings of the conference have been published in two volumes, the first and larger of which, dealing with medical and physiological applications, is reviewed here.

The proceedings contain seventy-one papers together with the discussions which followed their presentation in conference and deal with a very wide range of techniques and applications. The papers are grouped under three main headings: therapy and diagnosis; biochemistry and metabolic studies; and plant biochemistry. Papers grouped under the first heading deal mainly with the use of iodine-131 in the diagnosis and treatment of abnormal thyroid function, and the use of such isotopes as phosphorus-32, cobalt-60, and cerium-144 as beta- and gamma-ray sources in irradiation therapy. Papers under the second heading deal with the use of radioisotopes in biochemical and physiological research and cover such subjects as the use of 'labelled' proteins in immunochemistry and the determination of sodium and potassium in invertebrate nerve fibres by activation analysis. The third and smallest group of papers deals mainly with the uptake and distribution of phosphorus-32 in plants either as fertilizer or as labelled insecticides. The discussions were frank and constructive, and in some cases constituted a salutary addendum to the preceding paper.

The papers dealing with the medical applications of radioisotopes in diagnosis and therapy suggest that much has yet to be learned about the use of pile-produced radioisotopes for the selective destruction of tumours *in vivo*. As a diagnostic aid and also in small doses for the clinical appraisal of metabolic behaviour, radioisotopes appear to be well established with considerable potentialities. The papers illustrate clearly that, in biochemical, physiological and agricultural research, radioisotope techniques have constituted a major advance in recent years: for example, in the study of precursor–product relations in steady-state systems—an important problem scarcely soluble except by isotope tracer techniques. Many useful and novel techniques are described for the location of radioisotopes in large animals, in plants, on paper chromatograms and in histological sections. Some of the complications of radioisotope applications also receive attention, such as the difficulties of constructing directional counters, collimating powerful gamma-ray sources and the importance of recognizing radiation effects in labelled fertilizer studies.

The standard of the papers is high for a conference of this sort, when sometimes papers are thinly disguised excuses for participation at a conference. Surprisingly few typographical errors have been noticed. Two papers mysteriously appear in the wrong section (pp. 379 and 381), and the title "Chromatographic Techniques" includes a curious range of subjects. The proceedings provide a unique review of recent developments in radioisotope applications not to be found in current text-books on the subject. Moreover, they provide an indication of future developments, by whom and where, which is of particular value to the radioisotope specialist. Although a more recent conference on radioisotope techniques was held in 1954, it seems unlikely to vitiate the value of the published proceedings of the 1951 conference.

F. P. W. Winteringham

THE INTERNATIONAL GEOPHYSICAL YEAR, 1957–58

By Prof. SYDNEY CHAPMAN, F.R.S.

A DESCRIPTION was given in *Nature* of August 22, 1953, of the inception and progress of the plans for the world-wide enterprise entitled the International Geophysical Year. This is a successor to the two International Polar Years of 1882–83 and 1932–33. It follows the latter after twenty-five years, instead of the fifty that elapsed between the two Polar Years. It covers the whole globe instead of being specifically devoted to the polar regions, and its scientific scope is far wider than that of its predecessors. They fell near sunspot minimum; the International Geophysical Year will be at or near sunspot maximum, and its duration will be eighteen months, from July 1, 1957, to December 31, 1958.

The International Council of Scientific Unions is the official sponsor of the enterprise, which it has adopted for the time being among its 'permanent services'; important financial support for the central organization is afforded also by the United Nations Educational, Scientific and Cultural Organization. The Council has appointed a Special Committee to provide the central direction and co-ordination of the efforts of the many nations participating in the International Geophysical Year. The Committee—known by the initials of its French title as CSAGI (Comité Spécial de l'Année Géophysique Internationale)—is constituted on a functional, not national, basis, being composed as follows of persons representing the international scientific bodies indicated: (International Council) L. V. Berkner (vice-chairman), S. Chapman (chairman), E. Herbays and M. Nicolet (general secretary; at 3 Avenue Circulaire, Uccle, Belgium); (International Astronomical Union) A. Danjon and Sir Harold Spencer Jones; (International Union of Geodesy and Geophysics) J. Coulomb, G. Laclavère, V. Laursen and P. Tardi; (International Union for Scientific Radio) W. J. G. Beynon and M. Boella; (International Geographical Union) J. M. Wordie; (International Union of Pure and Applied Physics) J. A. Simpson and S. Vallarta; (World Meteorological Organization) J. Van Mieghem and T. E. W. Schumann. The Joint Commissions on Solar and Terrestrial Relationships, and on the Ionosphere, of the International Council are linked with the Special Committee through its members Nicolet and Beynon.

The Special Committee held its first full meeting in Brussels in July 1953, together with some representatives of the national committees formed at the invitation of the International Council through Colonel E. Herbays, the provisional secretary and convenor of the Committee, at its preliminary meeting in October 1952. At Brussels in 1953 the Special Committee considered reports and proposals from twenty-one national committees and from the Unions of Geodesy and Geophysics and of Astronomy, and from the World Meteorological Organization; these documents, and the agenda for the meeting, were published in the IUGG News Letter in its quarterly issue (Vol. 2, Part 3) of July 1953. The proceedings, provisional programme and resolutions of the Special Committee, together with four additional national reports, appeared in the October 1953 issue of the News Letter. This completed the first stage of the plans for the International Geophysical Year.

The Special Committee held its second full meeting at Rome during September 30–October 4, 1954, in the palace (and by the courtesy) of the Italian National Research Council. Between this and the 1953 meeting the national committees reviewed and developed their plans for the International Geophysical Year, in order to present revised reports to the Rome meeting. The general secretary issued invitations to countries that had not yet decided to take part in the International Geophysical Year to participate in the enterprise, and to prepare plans in the light of the provisional programme drawn up in 1953. The associated international bodies represented on the Special Committee were also requested to give further consideration to the programme and plans. They and the adhering nations were requested to send members to attend the Rome meeting to assist the Special Committee in its discussions. During the summer of 1954 meetings were held by the International Unions of Pure and Applied Physics, of Scientific Radio, and of Geodesy and Geophysics, as also by the Joint Commissions on the Ionosphere and on Radio Meteorology; at all these, active consideration was given to the plans for the International Geophysical Year.

These intensive preparations bore good fruit. Those attending the Rome meeting of the Special Committee numbered slightly more than a hundred, drawn from about thirty nations. Almost all those present took an active part in the discussions of one or other of the many working groups which considered the various branches of the programme. The documents resulting from the arduous labours of the first three days of the meetings (Thursday – Saturday) were prepared by the secretariat during the Sunday recess, and presented to a plenary meeting on October 4.

At the outset of the meeting, the general secretary was able to report that thirty-six nations had formed national committees, and that the formation of others was pending. During the meeting the officers were informed by the Embassy of the U.S.S.R. in Rome that the Academy of Sciences of the U.S.S.R. had responded to the invitations sent to it to participate in the International Geophysical Year, and had appointed a national committee for the purpose, under the presidency of Academician Gemburzev, director of the Geophysical Institute of the Academy; also that a U.S.S.R. delegation of eleven members, who as guests had attended the General Assembly of the International Union of Geodesy and Geophysics held in Rome during September 1954, had been appointed also to attend the meeting of the Special Committee. Members of the delegation indicated that the U.S.S.R. Academy of Sciences would co-operate also in encouraging

other nations to participate in the International Geophysical Year.

The principles so far tacitly applied in the selection of items for the programme of the International Geophysical Year were explicitly formulated at Rome as follows: the first priority is given to problems requiring concurrent synoptic observations at many places on the globe, involving co-ordinated effort by many nations; second come geophysical problems the solution of which will be aided by the availability of the results of synoptic or other concentrated geophysical work undertaken during the Year; a third principle is that where the main programme involves the occupation of stations in regions of the earth to which comparatively little geophysical effort has been devoted, advantage should be taken of the opportunity to make observations also of other major geophysical phenomena, for example, earthquakes; fourthly, geodetic and other observations will be made of slowly varying geophysical phenomena, for comparison with similar future observations at later epochs.

During the International Geophysical Year the most modern types of observation of many kinds, for example, meteorological, ionospheric, magnetic and auroral, will be more widespread over the globe, and made with greater frequency, than ever before. But even during this period there will be intervals of specially intensive observation. Definite plans have been formulated for the choice of these intervals, subject to final adoption by the Special Committee at its meeting in 1955. The intervals include three Regular World Days each month, of which two will be at new moon and one near the quarter moon; these have now been designated—they include days of predictable events such as solar eclipses and meteor showers. In the field of meteorology there will be six World Meteorological Intervals of ten days each, one in each period of three months, near equinox or solstice; each such interval includes the three Regular World Days during the month in which it occurs.

There are some geophysical phenomena, however, the occurrence of which cannot yet be predicted with much probability (if at all) more than a few days ahead, namely, magnetic and ionospheric storms and auroræ, which are dependent on solar flares and other exceptional events on the sun. Great magnetic storms are associated with the appearance of auroræ visible from regions far outside their usual limits—perhaps the most outstanding case was that of February 4, 1872, when a brilliant aurora was seen from the greater part of the globe, including Bombay and Aden. It is hoped that if any such events occur during the Geophysical Year—and this may be expected—they will be properly observed, for the first time in geophysical history. Careful plans are being made to achieve this, and to enable ionospheric and magnetic observatories to give to such phenomena the special attention that is their due. To this end there will be close co-operation between the solar observatories that will keep a close and (it is hoped) continuous watch on the sun, and the organizations that now make predictions of ionospheric and magnetic conditions; when the state of the sun indicates the likelihood of geophysical disturbance a few days ahead, a World Alert Period will be designated, and notified the world over by radio and other means of communication. When the continuing developments on the sun render it suitable, a Special World Interval will be declared about 12 hr. in advance, to continue until terminated by the predicting agencies. These agencies will also give world-wide notice of the commencement of great geophysical disturbances that may occur without having been foreseen. Through these procedures it is hoped that detailed observations of the morphology of these disturbances will be possible, and that even down to low latitudes, preparations for proper auroral observation will be made. It is hoped that, in co-operation with centres elsewhere, the U.S. Central Radio Propagation Laboratory will undertake to designate and notify these special periods.

The principal fields of geophysical science to be cultivated during 1957–58 will be meteorology, ionospheric physics, geomagnetism, the aurora and airglow, and cosmic rays; astronomical institutions will give essential assistance through solar observation and their geodetic work on determinations of latitudes and longitudes. Some effort will also be devoted to oceanography, glaciology and seismology. An important programme of rocket observations has been formulated. In this work the chief participant will be the United States; but it is hoped that some other countries will also be able to arrange co-operation in rocket studies of the upper atmosphere.

Careful attention was given at the Rome meeting to the geographical distribution of observing stations planned or desirable, in order to detect important gaps, with the view of seeking means of filling them, and also recommending combination or elimination when unnecessary duplication might occur. Areas to which special effort will be devoted are the Arctic and Antarctic caps and the tropical zone, together with three special meridians, 70–80° W., 10° E. and 140° E. It appears that only minor changes in the programmes proposed by the various individual nations will suffice to achieve an excellent world geophysical network.

The measure of co-operation envisaged will, if executed, make the International Geophysical Year by far the most extensive and important international scientific enterprise yet accomplished.

Gradually public knowledge of the plans for the International Geophysical Year is being spread by newspaper and magazine articles in many countries. The U.S. Congress has made generous financial provision for the preliminary stages of American participation, which will be under the ægis of the National Scientific Foundation. President Eisenhower, in a public statement, has warmly endorsed this far-reaching effort as one that will "very materially strengthen our bonds with the many co-operating nations and make a constructive contribution to the solution of mutual problems". His Holiness Pope Pius XII has likewise commended the enterprise as one likely to contribute to a more peaceful and co-operative attitude among the peoples of the world, as well as to their material betterment.

The countries participating in the International Geophysical Year, in alphabetical order according to the English versions of the names of the countries, are as follow (up to October 1, 1954): Argentina, Australia, Austria, Belgium, Brazil, Britain, Canada, Czechoslovakia, Denmark, Finland, France, Germany (Eastern), Germany (Western), Greece, Holland, Iceland, India, Ireland (Eire), Israel, Italy, Japan, Mexico, Morocco, New Zealand, Norway, Pakistan, Peru, Philippines, Russia (U.S.S.R.), South Africa, Spain, Sweden, Switzerland, Tunis, United States (U.S.A.), Yugoslavia.

PRECISION ELECTRICAL MEASUREMENTS

A SYMPOSIUM having as its general theme the techniques of precision electrical measurement was held at the National Physical Laboratory during November 17–20. Twenty-six papers were read and discussed, the authors being drawn from a particularly wide field, including not only some of the principal electrical laboratories in Britain but also members of the national laboratories of Australia, South Africa and the United States, and well-known workers from Germany, Holland and Sweden. In opening the proceedings, Dr. P. Dunsheath remarked that precision is evidently used as a relative term, for the errors recognized in, say, some of the magnetic and high-voltage techniques would fill those dealing with more manageable techniques with horror. Indeed, the subsequent discussion showed that mere statements of percentage accuracy are seldom of much interest; the important points are those which ensure that an experiment does in fact satisfy the conditions postulated in asserting that the quantity measured is such-and-such.

The symposium was divided into five sessions which dealt successively with subjects that form substantial items in the work of the Electricity Division of the National Physical Laboratory and that bear more or less directly on industry. The first session was devoted to the techniques applicable to electric fields and dielectrics; the second to magnetic fields and associated materials; the third dealt with electrotechnical measurements; the fourth with standard techniques for the high-voltage laboratory; and the last with the techniques of impulse-testing.

Perhaps the most outstanding feature of the techniques for the measurement of dielectric constant and power loss discussed in the first session was the range of frequency covered. Various aspects of the standard bridge and resonance techniques were introduced by Dr. L. Hartshorn and E. Rushton and J. V. L. Parry, of the National Physical Laboratory. Dr. M. Gevers, of the Philips Research Laboratories at Eindhoven, emphasized the versatility of standing-wave methods for the microwave range, and it appears that these are superior to cavity resonator methods for materials of high loss, though the cavity has the advantage for low-loss materials. D. Woods, of the Ministry of Supply, showed that a bridge of the twin-*T* type can be constructed to give high precision at frequencies up to 300 Mc./s. At such frequencies, however, a massive block of brass used as the junction of two or more arms of the bridge is no longer an equipotential; it must be represented on the bridge diagram not as a mere junction point but as a network of small inductances. On paper, therefore, the bridge network opens out formidably, while the concrete reality shrinks to a closely interlocked group of brass blocks and cylinders the construction of which calls for mechanical work of very high precision. This indeed is a limitation of the technique, though its value for the particular purpose of calibrating standard coaxial components is obvious.

Considerable interest was also shown in techniques applicable to dielectric behaviour at extremely low frequencies. Dr. G. Mole and D. C. G. Smith, of the Electrical Research Association, described an a.c. bridge which is conveniently workable at frequencies down to 0·05 c./s.; but the discussion showed that d.c. techniques are usually preferred for general work in this region, if only because, as C. G. Garton mentioned, time constants of the order of 50 hr. have been observed, and for periodic times of this order a.c. methods become quite impracticable.

Much of the discussion in the second session was concerned with various forms of permeameter used for determining the characteristics of industrial materials. C. E. Webb, of the National Physical Laboratory, dealt with standard methods for the delineation of magnetization curves. The discussion showed that the ballistic method is almost universally employed for the curves which serve as a basis for industrial design, and the discussion dealt largely with fine detail. Dr. M. McCaig, of the Permanent Magnet Association, stressed the difficulty of winding magnetic potentiometers with adequate uniformity and described a test that had revealed unsuspected errors in all such coils however carefully they had been wound. Prof. J. Greig and others mentioned the growing importance of methods for integrating and recording slow changes of flux and thus delineating individual cycles of magnetization, as a supplement to the ordinary curve for the steady cyclic condition that is determined point by point by the ballistic method; the two are clearly not necessarily the same and the differences are likely to be instructive. A paper by T. M. Palmer, of the Australian National Standards Laboratory, described a magnetometer in which a saturable core consisting of a short length of mumetal wire is used as a probe. The probe is small enough to serve as a null-detector for the measurement of H in a permeameter and it therefore offers an interesting alternative to search-coil methods; but its advantages have so far only been established for measurements of the earth's field and the like.

Methods for use at communication frequencies were described by A. C. Lynch, of the Post Office Engineering Research Station, and by P. H. Haas, of the U.S. National Bureau of Standards. Such methods depend on measurements of the inductance and equivalent resistance of toroidal cores provided with a suitable winding, the contribution of the winding alone being calculated or measured separately after removal of the core. The nature of the winding is an important factor; Mr. Haas places the core in a metal chamber which when closed by a cap forms a single short-circuited secondary turn; Mr. Lynch prefers a wire winding of three discrete turns; and Dr. C. M. van der Burgt, of the Philips Laboratories, showed an alternative scheme, by which a silver winding can be opened and closed for the insertion of the toroidal core, without introducing any uncertainty into the resistance of the winding, which is an extremely important factor.

A paper by R. L. Driscoll, of the U.S. National Bureau of Standards, described the determination at that laboratory of the magnetic moment of the proton (or more strictly its gyromagnetic ratio) by means of nuclear resonance. This brought microwave techniques and frequency measurement into the picture, and introduced the idea that the proton may conceivably serve as a magnetic standard accessible to everybody who can command the technique. The resonance frequency being determined only by the product of a constant characteristic of the proton and the field strength, it becomes possible to measure magnetic fields by observations of a

frequency of resonance in water or any suitable material rich in protons used as a probe. At the National Bureau of Standards the field is actually measured in present-day units by weighing the force on straight conductors of accurately determined length suspended in it. The method is no doubt the best available for strong fields. For weaker fields it is probable that greater accuracy could be obtained by producing the field by passing a measured current through a primary standard inductor. The use of such an arrangement as a basis for magnetic measurements, and in particular for the calibration of search coils, was discussed in a paper by G. H. Rayner, of the National Physical Laboratory.

The electrotechnical session began with the recognition that the accuracy of all measurements depends on the constancy of the quantities involved. Two aspects of the underlying problem were discussed, namely, the constancy of a.c. generators and that of the alloys used for the construction of standard resistors. It became clear that electronically stabilized supplies are coming into general use in standards laboratories, and the system described by B. V. Hamon, of the Australian National Standards Laboratory, provided a good example; two 3-phase, 12 kVA. alternators have automatic control of both frequency and voltage to about 0·01 per cent at any setting in the working range. C. Petersen, of the U.S. National Bureau of Standards, reviewed the work on resistors, and great interest was shown in the subject. It became evident that an alloy of exceptionally high resistivity and adequate stability has been sought in vain by many, that manganin still holds its place for stability, with constantan as an alternative that is almost indispensable for a.c. work, and that modified nickel–chromium alloys show promise of higher resistivity with stability. The remaining papers centred around the problem of the d.c. to a.c. transfer standard. In theory no standard is necessary; instantaneous values are measurable by direct reference to d.c. standards, but practice is mainly concerned with steady-state values, and the accuracy required is much greater than can be obtained for instantaneous values. Hence the importance of the stabilized supply mentioned earlier, and the transfer standard which indicates with precision either d.c. or stationary root mean square values. Examples of the three types now in use were discussed: a dynamometer wattmeter constructed by Dr. O. Brune and J. W. Whittaker at the National Physical Laboratory, South Africa; thermal instruments used as ammeters and voltmeters at the U.S. National Bureau of Standards described in a paper by F. L. Hermach; and the electrostatic wattmeter used at the National Physical Laboratory and described by Dr. A. H. M. Arnold with particular reference to work at audio-frequencies.

On proceeding to higher voltages, the same considerations apply with the additional complications that clearances must be made larger to avoid breakdown so that the equipment tends to become excessively bulky, resistors of extremely high value become necessary to avoid excessive power dissipation and transients as well as steady-state values are often required. The compressed gas capacitor, discussed by Dr. A. Keller, of Hartmann and Braun A.G., Germany, well illustrates one answer to the problem of keeping down the bulk of the equipment. Single units containing carbon dioxide at 14 atmospheres pressure have now been made to withstand an operating voltage of 900 kV. (r.m.s.), with a capacitance of 65 pF. They serve as standards for the measurement of dielectric loss at high voltage. G. W. Bowdler, of the National Physical Laboratory, discussed methods for the measurement of high voltages in steady-state conditions, especially the construction of resistors of high value, and potential dividers, and the use of the attracted disk electrostatic voltmeter, which with compressed gas insulation has been used up to 600 kV. (peak). P. R. Howard, of the National Physical Laboratory, dealt with the measurement of transients. It is, of course, the cathode-ray oscillograph that has made such measurements possible, but accuracy depends largely on the proper control and assessment of stray capacitance and inductance in the auxiliary equipment of voltage divider and cables between the instrument and the point of the system under investigation. F. S. Edwards, of the Metropolitan-Vickers Electrical Co., Ltd., discussed the sphere-gap as a peak voltmeter. Most speakers saw something incongruous in the basing of a standard on anything so erratic and violent as an electric spark; but the fact that standard calibrations for the sphere-gap have been issued in Britain, the United States and Germany is evidence of its practical importance for the measurement of very high voltages and of the need for a knowledge of the ways of minimizing the errors and estimating their magnitude.

The final session was devoted to a discussion of impulse tests on high-voltage equipment. At first sight the problems are somewhat remote from precision measurement. The objective is a proof of the ability of a transformer, cable or other insulated system to withstand surges of voltage such as are liable to arise in practice from lightning strokes or switching operations. Surges of suitable severity must be generated, applied at specified points, and the currents or voltages at key points must then be examined for any departure from normal behaviour such as could arise from partial failure. The whole problem is of such intricacy, including as it does the recognition and interpretation of special features in transients in complicated systems of inductance, capacitance, etc., that the techniques are far less standardized than are those of a measurement. However, the discussion showed that the techniques have much in common with those of measurement. The distribution of transients within a complex network, for example, is determined by factors exactly similar to those in a high-frequency bridge. The problem of the common junction point in Mr. Woods's bridge discussed in the first session has its counterpart in the common 'earth' of an impulse-testing system, and the proper location of earth capacitance and residual inductance provides the solution in both cases. The details, however, defy summary treatment. W. G. Standring, of the National Physical Laboratory, presented a general survey of the problem; N. Hylten-Cavallius, of A.S.E.A., Sweden, an account of the design and construction of surge generators; G. H. Hickling, of C. A. Parsons and Co., Ltd., J. Neuve-Eglise, of Electricité de France, and P. G. Provoost, of K.E.M.A. Laboratories, Holland, each recorded experience of the detection of faults in transformers; and B. Salvage, of W. T. Henley's Telegraph Works Co., Ltd., discussed the corresponding problem for cables and their accessories.

The complete proceedings will be published as soon as practicable and will be obtainable from H.M. Stationery Office.

L. Hartshorn

BRITISH IRON AND STEEL RESEARCH ASSOCIATION

OPEN DAY AT THE BATTERSEA LABORATORIES

THE importance of both theoretical and applied research to the maintenance of Britain's industrial position is being increasingly recognized to-day, and the iron and steel industry, which can fairly be described as the core of the entire British industrial complex, is particularly conscious of the vital bearing of research on economic efficiency. The extensive facilities of many industrial firms were further reinforced by the formation in 1945 of the British Iron and Steel Research Association. Besides laboratories at Sheffield, Normanby and Swansea, where practical problems can be tackled in the heart of the appropriate industrial centre, much theoretical and supporting work is carried out by the London laboratories of the Association, notably those at Battersea. Something of this work, chiefly that of the Plant Engineering Division and the Physics and Chemistry Departments, was on view on November 18 and 19, when there were open days at the laboratories. Besides fundamental research into their own special subjects, the groups concerned support the general work of the Association's other Divisions. The short notes which follow give a brief survey of a selection of these projects illustrated at Battersea.

Plant Engineering. The Electrical Engineering Section of the Plant Engineering Division has recently been studying the relation of the operator to his working environment in an attempt to match the control to his abilities, thus achieving a higher working efficiency for the manually controlled machine. The work arose out of earlier crane studies which showed that controls were often badly arranged, difficult to manipulate quickly, and lacking in realism—that is, handles did not move in the direction of motion. Re-design of the master controller itself allowed a much more compact grouping of the controls around the operator, and provision of a work seat designed by Dr. H. Darcus, of the Department of Anatomy, University of Oxford, helped to improve the operator's working conditions. Attention was then turned to the design of the crane cab itself, with the result that visibility was much improved. As a result of this first phase of the work, a series of suggestions were published[1], many of them quantitative, on the design of controllers and control points in steelworks.

In 1953 a Mutual Security Aid grant was obtained to continue and extend this work. Attention has been given to the design of foot controllers, about which little is known, and which have great potential value where several controls have to be operated by one man. Experimental equipment has been designed consisting of one of the new controllers equipped with an adjustable foot-pedal and connected to a motor driving a visible jockey. Several operators were trained to move this jockey via the foot control, so as to make it coincide with a hand-set jockey, and were then given tasks of adjusting the device to different set points for a given period each day. All foot movements were recorded on teleprinter tape, and subsequent analysis has enabled the best position of the foot-pedal pivot, relative to the ankle point, to be determined approximately. This work is being continued, and it is proposed also to compare the relative merits of pivoting and 'push' type foot controllers.

Quite wide divergencies still exist in hand controllers in the angle of movement, spacing of steps, length of handle, force required to operate the handle, and type of handle grip. In an attempt to determine the optimum conditions, a special controller has been made in which these factors can be varied. Here again, the operators' success in controlling a jockey with the hand controller will be measured and will form the criterion by which the quality of the control will be assessed.

Chemistry Department. The presence of nitrogen is a contributory factor in the development of ageing phenomena and in causing poor magnetic qualities in silicon–iron transformer sheets. Alloying elements can overcome these effects in some degree by encouraging the formation and precipitation of free nitrides from the solid solution of nitrogen in iron. The problem centres, therefore, on a more exact knowledge of the effect of these alloys and the conditions under which free nitride phases can be formed. Experiments are in progress in which alloy steels are progressively nitrided at various temperatures in order to discover when nitride phases are produced.

The Refractories Section is investigating the composition and performance of lining materials. Very little is known about the influence of mechanical and flow properties of basic bricks, particularly when heavily contaminated, on their behaviour in a furnace roof. Measurements of crushing-strength are being made at temperatures up to 1,100° C. on specimens cut from used bricks. At this temperature the materials still behave elastically. In addition, a study is being made of the plastic properties at higher temperatures under different rates of strain corresponding to various rates of bursting expansion or lateral compression.

The Corrosion Section exhibited many specimens from field trials of various methods used for protecting iron and steel from corrosion in the atmosphere, in salt water, and in soil. An interesting piece of equipment is the rotor test apparatus which has been built to facilitate laboratory study of the corrosion factor in iron and steel exposed to flowing water. The liquid medium can, of course, be varied, and different natural conditions can be reproduced as the investigation requires. By rotating the specimens at speeds up to 15 knots, the effect of corrosion on moving ferrous objects—such as ships' hulls—can be simulated. The flowing liquid also substantially speeds up the onset of corrosion, a factor of some importance in facilitating investigations.

Physics Department. Two important advances have been made in steelmaking processes as a direct result of research work in the Physics Department. The continuous casting of steel has long been recognized all over the world as likely to have considerable economic advantages over conventional ingot casting. Research has been carried out for the past few years in the London laboratories, and its outcome is an experimental production plant, which began operation in April 1954, for the continuous casting of special steels in a member's works. This is the first two-strand plant ever to be operated by the British steel industry, and it provides a very good example of co-operation between a research association and its industry. Eleven interested companies have formed a development group to finance the capital and running costs of the continuous casting installation.

A second advance has been the development of a new burner for oil or oil and coke-oven gas used in open-hearth furnaces. A study of existing burners in which the fuel was atomized at the back end of the burner showed that a high proportion of the input energy was being wasted. Measurements of the momentum-producing efficiency showed that it was better to dispense with back-end atomizers, and to allow liquid fuel to be accelerated gradually towards the burner tip where atomization occurs. The Association's burner is thus very simple to construct. Trials on several open-hearth furnaces carried out jointly by the staff of member firms and the Association have shown very important improvements in increased productivity, longer furnace-roof life, a more efficient use of steam, and the lower cost of fuel per ton of steel produced.

The cleaning of industrial gas and fume is a topic of enormous national importance, and the Department is preparing to play an increasing part in the study of this problem. Fundamental work in 'particle capture' has shown that to be effective the water must be in droplets comparable in size to the dust particles, and the essential weakness of the existing spray method lies in the great variation in size of the droplets produced. An experimental unit was therefore devised incorporating spinning disks, in which the gas passes through an annulus surrounding five disks on a common shaft, rotating at speeds up to 5,000 r.p.m. The gas then passes through a bank of irrigated cyclones to remove the water droplets carried forward. For particles 1–76 μ in diameter, overall efficiencies exceed 98 per cent, but this falls to about 60 per cent for particles less than 1 μ in diameter. Further work is being carried out to improve this performance.

Dust-laden gases from many industrial processes are being studied, and valuable data are being accumulated. This will help in selecting suitable plant for specific conditions, and in estimating the efficiency of various types of cleaning plant.

[1] Bramley, L. N., *J. Iron and Steel Inst.*, **173**, 53 (Jan. 1953).

THE NEW MEGAVOLTAGE RADIOTHERAPY UNIT AT MANCHESTER

THE Christie Hospital and Holt Radium Institute, Manchester, the largest radiotherapy centre in the world, has recently received important additions to its X-ray equipment, in the form of a 4-million volt linear accelerator and a 20-million volt betatron. Both machines were made by the Metropolitan-Vickers Electrical Co., Ltd., at Trafford Park, Manchester, the former being purchased by the Ministry of Health as part of a plan to equip key radiotherapy centres with this type of apparatus. The betatron is the gift of the makers to the Christie Hospital.

The machines are housed in a specially designed building, provided by the Medical Research Council, which is also financing the work to be done with them. This building provides the usual patients' waiting rooms, examination rooms and medical offices, and also a workshop, photographic dark-room and a number of laboratories. Some of these will be used by the physicists attached to the department, while others can be occupied by teams from the main research laboratories of the Christie Hospital, when they are working with the megavoltage radiations. Since it will be necessary to compare the effects of the high-energy radiations with those of the familiar 'deep therapy' range (200–300 kV.), the new department also has a 300-kV. 'Resomax' X-ray tube for this comparison work.

The linear accelerator is of the travelling wave type[1], in which electrons are accelerated by 'surf-riding' on radio waves, the speed of which increases down a corrugated wave-guide. For the acceleration of electrons to an energy of 4 MeV. a tube of only 1 metre long is needed, and this can be mounted on a single-ended gantry-type of mounting (Fig. 1), which can be swung about a horizontal axis, so that the X-ray beam can be aimed in any direction from 15° beyond the downward vertical to 15° beyond the horizontal (a total swing of 120°). Collimation of the beam is by means of adjustable diaphragms of lead, lined with tungsten 'heavy' alloy; treatment fields (at 1 metre) varying from 4 cm. × 4 cm. up to 25 cm. × 30 cm. can be obtained. Circular fields are obtained by inserting lead blocks, pierced by conical holes, between the jaws of the collimator. Since for megavoltage radiations the intensity falls off rapidly on either side of the central axis of the beam, a conically-shaped filter has to be used to produce a uniform field of irradiation. Under such conditions, dose-rates up to 200 r. per min. at a metre from the target can be obtained.

In the betatron[2], the first of its kind to be used in Britain for medical purposes, electrons are accelerated as they circle around inside a magnetic field which is increasing sinusoidally. The electrons reach their maximum energy in 1/600 sec., in which time they have travelled some 300 miles, gaining 80 eV. of energy on each of their 250,000 revolutions around the magnetic field. The magnet, which weighs 7½ tons, and the acceleration vessel or 'doughnut', are mounted so that they can rotate through an angle of 120° about a horizontal axis (Fig. 2). Thus the X-ray beam can be fired in any direction from 15° above the horizontal to 15° beyond the vertical downwards. In addition, the framework carrying the magnet can be raised or lowered through a distance of 7 ft., so that the machine has all the freedom of movement required for radiotherapy.

The collimation of the beam in this machine is by means of cylinders pierced by suitable conical holes, inserted through the lead protective wall placed in front of the doughnut. So that these cylinders shall not have eddy currents induced in them by the changing magnetic field, and yet provide adequate radiation shielding, they are made of a mixture of lead shot and lithage. Each will carry its own compensating filter to give a uniform intensity of radiation across the treatment area.

The beam at 20 MeV. is even narrower than at 4 MeV., and therefore the maximum field reasonably attainable is much smaller than with the linear accelerator, and is a circle of 13 cm. diameter at 1 metre. With the compensating filter in position, the betatron delivers about 50 r. per min. at a metre from the target.

Though these new machines will be used in the Hospital's main research programme into the action of radiations on living tissue, and though the irradiation of biological materials will serve as an invaluable aid in deciding correct dosage for the treatment of patients, the main function of the new equipment is the treatment of cancer.

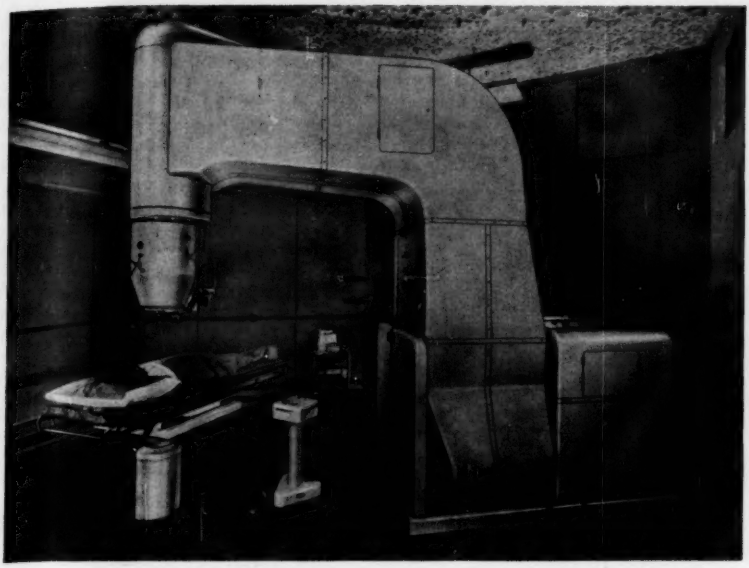

Fig. 1. Metropolitan-Vickers 4-MeV. linear accelerator with X-ray beam in vertical position

In radiotherapy, it is often necessary to treat a cancer growing deep in the body. To do this an adequate dose of radiation must be delivered to the tumour area without overdosing other parts of the body. This is usually achieved by using a number of X-ray beams aimed at the tumour from different directions. The more penetrating the X-rays, the fewer the number of beams that have to be used, or the smaller the dose which each beam has to give to the normal tissue through which it passes.

Since the penetrating power of a beam depends on the voltage used for its generation, the first advantage offered by megavoltage radiations is increased penetrating power, and hence the ability to treat deep tumours much more efficiently. The radiations, however, have other considerable advantages. One is that they are less scattered than are lower-energy rays, and thus the amount of radiation received by tissues outside the geometric confines of the beams is greatly reduced. Another advantage arises from the behaviour of the electrons set in motion by the attenuation of the X-ray beam in the material through which it passes and which are responsible for most of the effects of the radiation. These travel predominantly forward in the direction of the beam, and, giving up most of their energy at the end of their track, produce the highest dose some distance below the surface. For 4-million volt X-rays, the maximum is about 1 cm. below the surface, while for 20-million volt X-rays it is as much as 4 cm. deep. With these radiations, therefore, the effect on the skin is greatly reduced and skin reactions, so troublesome at 250 kV., are practically eliminated. A further advantage arises from the fact that scattering, which depends but little on atomic number, is the predominant mechanism by which the beam is attenuated at these energies, and thus the absorption of the rays in bone and in soft tissues is much more nearly equal than it is at lower voltages. Therefore there is far less danger of overdosing bones and of underdosing, because of the shadow effect, tissues which lie beyond bone.

While these physical advantages are firmly established, the biological effects of the megavoltage radiations are not so certain. It appears likely that they will be similar to those produced by the familiar 250-kV. range of X-rays, but this is not certain. Some biological effects are dependent on the linear ion density of the radiation, and since this is smaller for megavoltage radiation than for 250 kV., this may have some influence. Further, both machines produce

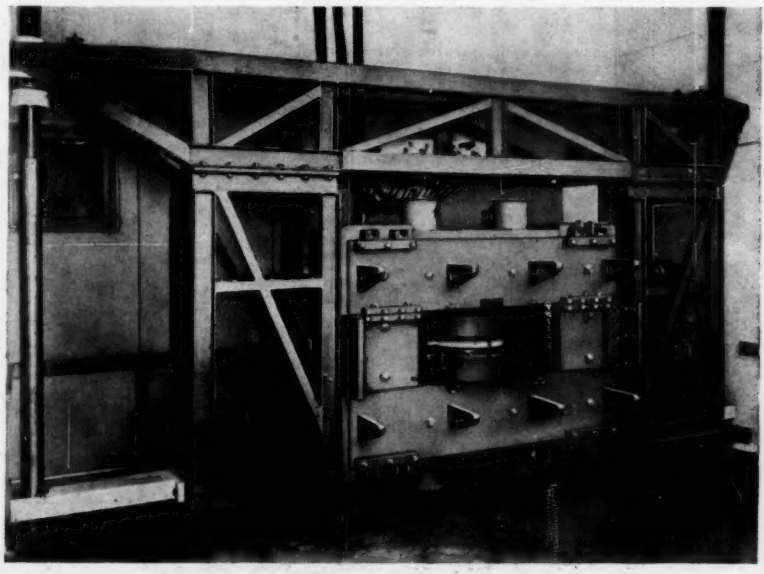

Fig. 2. Metropolitan-Vickers 20-MeV. betatron during installation

radiation in pulses of very short duration, and hence of high instantaneous dose-rate instead of the approximately uniform dose-rate of the conventional equipment, and this again may cause differences. The evidence so far available, in fact, suggests that the high-energy X-rays are slightly less efficient than lower-energy ones in producing some biological effects. Therefore clinical work with the two machines is going forward very cautiously, supported and guided by the results of comparison experiments using various biological and chemical indicators.

It must be stressed that the new machines do not offer any prospect of miraculous cancer cures; but it is confidently hoped that they will increase the proportion of cures already being attained with lower-voltage apparatus. Of one thing there can be no doubt: this unit offers unique opportunities for the study of the effects of ionizing radiations in malignant diseases.

[1] Fry, D. W., *et al.*, *Nature*, **160**, 351 (1947). Miller, C. W., *Nature*, 171, 297 (1953).
[2] Kerst, D. W., *Phys. Rev.*, **60**, 47 (1941).

OBITUARY

Prof. G. H. Shull

The death occurred recently of Prof. George Harrison Shull. He was born in Clark County, Ohio, in 1874. After taking his B.S. degree at Antioch College he graduated Ph.D. at Chicago in 1904. His first post was that of student assistant at the United States Department of Agriculture, Bureau of Forestry. After this he was successively botanical assistant at the U.S. National Museum, assistant plant physiologist at Chicago, and botanical investigator at the Carnegie Institution of Washington, where he remained for eleven years. In 1915 he became professor of genetics at Princeton University, where he worked until his retirement in 1942.

Prof. Shull is principally known for his pioneer work on pure lines in maize, which laid the foundations of the huge hybrid-maize industry of the United States, based on the crossing of lines which had been inbred for long periods. But throughout his long and productive scientific career he worked extensively on a variety of topics. He concerned himself, among other things, with the heredity of sex in *Melandrium*, linkage and mutation in *Oenothera*, and with self-incompatibility in *Capsella*.

Many academic honours were conferred on Shull, including honorary doctorates from Lawrence College and Iowa State University. He was a member of, and took an active part in, the administration of the Genetics Society, the Eugenics Research Association, the Philosophical Society, and the Torrey Botanical Club, of which he was president in 1947.

Prof. Shull was among the few remaining workers in genetics who date back to the early years of Mendelism. A final word must be said about one of his most noteworthy characteristics. He devoted much time and thought to young workers and was always ready to draw on his vast knowledge and experience for their guidance. A simple, kindly and serene man, he will be much missed.

S. C. Harland

NEWS and VIEWS

New Year Honours

The following names of scientists and others associated with scientific work appear in the New Year Honours list:

Baron: Dr. E. D. Adrian, president of the Royal Society and also of the British Association.

K.B.E.: Sir John Stopford, vice-chancellor, University of Manchester; Dr. Owen H. Wansborough-Jones, chief scientist, Ministry of Supply.

Knights: Prof. Wilfrid E. Le Gros Clark, Dr. Lee's professor of anatomy in the University of Oxford; Prof. Leybourne S. P. Davidson, professor of medicine in the University of Edinburgh, and president of the Royal College of Physicians of Edinburgh; Dr. Keith A. H. Murray, chairman of the University Grants Committee; Dr. Oliver G. Sutton, director of the Meteorological Office (Air Ministry) and president of the Royal Meteorological Society.

C.B.: G. R. D. Hogg, Under-Secretary, Department of Scientific and Industrial Research.

C.M.G.: D. M. Balme, principal of University College, Gold Coast; B. A. Cash-Reed, attaché for food and agriculture at the British Embassy in Washington; Dr. R. Lewthwaite, director of Colonial Medical Research; Prof. W. L. Waterhouse, lately professor of agriculture in the University of Sydney, for services to the wheat industry in Australia; T. Y. Watson, Secretary for Agriculture and Natural Resources, Uganda.

C.B.E.: C. E. J. Biggs, director of agriculture, Tanganyika; C. S. Bryant, lately director of materials and explosives research and development, Ministry of Supply; Dr. C. J. Gadd, keeper, Department of Egyptian and Assyrian Antiquities, British Museum; Dr. M. W. Goldblatt, director, Industrial Hygiene Research Laboratories, Imperial Chemical Industries, Ltd.; Dr. A. W. Greenwood, director, Poultry Research Centre, Edinburgh (Agricultural Research Council); W. F. Grimes, director, London Museum; G. W. Lines, director of agriculture, Sierra Leone; P. McNee, director, Drainage and Irrigation Department, Federation of Malaya; Prof. R. Peers, emeritus professor of adult education in the University of Nottingham, chairman of the Central Committee for Adult Education in H.M. Forces; Miss Audrey I. Richards, director, East African Institute of Social Research, Makerere College, Uganda; F. S. Russell, secretary of the Marine Biological Association of the United Kingdom, and director of the Plymouth Laboratory of the Association; E. E. Shipton, explorer and mountaineer; Prof. C. H. Smith, professor of instrument technology in the Royal Military College of Science; Dr. E. L. Taylor, deputy director, Veterinary Laboratories, Ministry of Agriculture and Fisheries; Prof. G. F. J. Temple, Sedleian professor of Natural Philosophy in the University of Oxford; L. C. Wilcher, principal of the University College of Khartoum, Sudan; J. Wright, director of agriculture, Jamaica.

Instrument Technology in the Imperial College, London: Prof. J. D. McGee

The recent announcement that Dr. J. D. McGee had been appointed by the University of London to the University chair of instrument technology provides an interesting example of the expanding

activities of the Imperial College of Science and Technology. At an earlier period of its history, instrumentation had been represented there by the chair of instrument design held by the late Prof. A. F. C. Pollard; but on his retirement no successor was appointed. Prof. McGee's particular interests lie in the field of photoelectric, electronic and television techniques rather than in the mechanical design of instruments, and as head of the new post-graduate Section of Instrument Technology in the College, he will be responsible for the development and application of these and similar devices to physical problems.

Educated at the University of Sydney, and awarded in 1928 an 1851 Exhibition travelling scholarship, he worked for three years under Lord Rutherford at the Cavendish Laboratory. From there, he went to the research laboratories of Electric and Musical Industries, Ltd., where he first worked on the development of high-vacuum cathode-ray tubes for television picture reception and later directed the research group which had been given the task of developing the pick-up tubes used in television cameras. During the War he was especially concerned with infra-red image converter tubes, not only with their development in the laboratory, but also with their factory production and with their military application. After the War, Prof. McGee was in charge of the group at Electric and Musical Industries, Ltd., responsible for striking developments in television camera pick-up tubes, charge storage tubes and photoelectric electron multipliers. These techniques are likely to be exploited to great advantage in the new Instrument Technology Section of the College. A staff of wide experience is being recruited and will help to establish a senior school of instrument technology that can be expected to make major advanced contributions to science and industry.

Jacques Dubois (Jacobus Sylvius) (1478–1555)

Jacques Dubois, who died in Paris four centuries ago on January 13, 1555, was a humanist who made many original contributions to anatomy and helped to reform its teaching. The son of a weaver, he was born in 1478 at Louville near Amiens, from which town he derived his Latin cognomen Jacobus Sylvius Ambianus. As a student at the college of Tournay near Paris, he excelled in Latin, Greek, Hebrew and mathematics, invented machines for transporting water and wrote a popular French grammar. After studying medicine in Paris, he travelled widely to improve his knowledge of pharmacy. Despite his lack of a degree, which he was too poor to obtain, his success as a teacher was so great that the Paris medical faculty stopped his courses because they interfered with the regular schools. Sylvius then went to Montpellier, where he graduated in medicine on June 28, 1531, and on his return to Paris taught anatomy at the Collège de Tréguier, insisting that this subject can only be studied from the human body by eye and touch, and not by reading and description. Though he often followed Galen blindly, he succeeded in clarifying many of the garrulous and obscure passages. He frequently had five hundred pupils, who included Vesalius, Servetus, Conrad Gesner and Charles Estienne. He gave specific names, some of which are still in use, to the muscles which Galen had designated by numbers, described the valves in the veins, and the sphenoid bone, and was a pioneer in practising the art of injection. At the age of seventy-two he was appointed professor of surgery at the Royal College of Paris. The aqueduct and the fissure of Sylvius were described by another Sylvius (François de la Boë) a century later.

Zoological Society and B.B.C. Expedition to West Africa

The expedition organized jointly by the Zoological Society of London and the British Broadcasting Corporation returned to Britain just before Christmas from ten weeks field-work in Sierra Leone, bringing a large collection of animals and a considerable quantity of cinematograph films and sound recordings. The animals are for the Society's collection at Regent's Park, London, and the films and recordings are for the B.B.C.'s television service—some programmes have already been broadcast. One of the main objects of the expedition was to find the nesting habitat of *Picathartes gymnocephala*, a rare passerine bird the systematic position of which is obscure; this bird has seldom been seen alive by Europeans. The habitat was found in difficult hilly bush country, and in spite of the dense shade cast by the forest successful films were made of the birds on and near the nests, of the eggs and of the parents feeding the young by regurgitation. Sound records were also obtained of the voices of the birds in their natural surroundings, and a living specimen was captured and brought to London. Another species never before exhibited in captivity that was successfully sought and found is the brilliantly iridescent emerald starling *Coccycolius iris*. Small flocks of this bird were discovered in the open savannah country of the highlands in the north near the French border. Much interesting film was made of various invertebrates, including several species of ants such as the driver, fire and Matabele ants, mantids, nest-building Hymenoptera and termites, as well as many subjects among the vertebrates. A further series is of particular anthropological interest as it shows some of the ritual dances used in connexion with the initiation ceremonies of the secret societies that have such a powerful influence over the lives of the pagan natives. Lengthy sound-recordings of the music and songs accompanying these dances were also made. The Zoological Society and the B.B.C. hope that the results of this joint venture will justify the organization of further field-expeditions to other parts of the world in the future.

Pool of Spraying and Dusting Equipment

A pool of spraying and dusting machinery for use in the Colonial territories is being established by the Colonial Office, in co-operation with the Imperial College of Science and Technology and the machinery manufacturers, at the Imperial College of Science and Technology Field Station, Silwood Park, Sunninghill, Berks. Manufacturers of spraying and dusting machinery have been approached through the Agricultural Engineers Association and are co-operating in the establishment of the pool by the loan of suitable equipment. The College has for some years maintained a representative collection of spraying and dusting machinery for teaching and experimental purposes, and this collection will be incorporated into the pool, which will include equipment designed for agricultural, stored products and public health work. The pool will fulfil three purposes: (1) the instruction of students (especially students preparing to undertake work in the Colonies) of agriculture, entomology,

mycology, etc., in the different types of equipment, their use and maintenance; (2) the demonstration of the equipment to interested potential users in the Colonies; (3) the consideration of modifications to machinery to meet special conditions of tropical use. A comprehensive reference library of spraying- and dusting-machinery manufacturers' literature is to be formed for the use of visitors. A committee on which the Colonial Office, the Imperial College, and the Agricultural Engineers' Association are represented has been set up and is responsible for the running of the pool and for the selection of machinery offered by any manufacturers for inclusion in the pool. Mr. A. E. H. Higgins, Imperial College of Science and Technology, London, S.W.7, is in charge of the pool.

Hilger Journal

The first number of the *Hilger Journal*, published in November 1954, is an illustrated pamphlet of eight pages of which approximately one-quarter is devoted to abstracts of recently published papers on spectroscopy. The issue contains also an account of the Hilger equipment installed in the new research laboratories of the Quasic Arc Company, Bilston, Staffordshire, and an extract concerning the use of optical methods from a talk by Dr. J. Haslam, of the Plastic Division of Imperial Chemical Industries, Ltd., on physical methods in the analysis of plastic materials. With regard to a new and complete direct–direct spectrograph, known as a polychromator, the merits and demerits of the two main systems of spectrochemical analysis, photographic and direct reading, are explained. A special Schwarz thermopile which can be used as a replacement in certain types (not Hilger) of infra-red spectrometers has been designed and details of its application are to be studied; but meanwhile a preliminary catalogue description has been prepared and is available on request from Hilger and Watts, Ltd., 98 St. Pancras Way, London, N.W.1.

Central Leather Research Institute, India: News Bulletin

The Central Leather Research Institute, which was opened in Madras in 1953, is one of a chain of twelve National Research Institutes established by the Government of India under the ægis of the Council of Scientific and Industrial Research. The scope of its work is to "carry out research in all aspects of leather industry, to solve problems which confront particularly the Indian leather industry and also to contribute to the international leather research which is being directed to extend leather science". It has now issued its first monthly bulletin (1, No. 1; August 1954; pp. 26. From the Institute, Adyar, Madras-20. Annual subscription Rs. 9 or 18*s.*; single issues Rs. 12). It is stated that each bulletin will contain abstracts, research papers of the Institute, other articles on leather technology and trade advertisements. In this issue, there are two articles. The first deals with "Some Aspects of Leather Manufacture" and is by Prof. B. M. Das, a recognized authority of long standing. Reference is made to the work of the Institute on the use of native barks to replace imported wattle extract, the presence of different tannins in avaram bark, rapid sole-leather tannages, new syntans from Indian coal-tar distillation products, basic aluminium salts in spray-dried powder form and tanning agents from mineral oil. The second article describes the improvement of the tanning properties of mangrove liquors by modification of their acid and salt contents. The bulletin is well produced and of considerable interest in Britain, because the Institute seeks to improve the quality of the raw and crust-tanned hides and skins exported to this country.

Insecticide and Repellent Action of Certain Chemicals

A handbook giving the results of tests of insecticidal action and repellency on fifteen species of insects and arachnids of medical importance has been compiled by W. V. King, of the Agricultural Service of the United States Department of Agriculture, and published as Agriculture Handbook No. 69 under the title of "Chemicals evaluated as Insecticides and Repellents at Orlando, Fla." (pp. 397. Washington, D.C.: Govt. Printing Office, 1954; 2.25 dollars). Eleven thousand chemicals were included in the tests, each chemical being graded into one of four or five categories according to its efficiency. A brief description of the methods of testing is given. The results give some indication whether or not the chemical tested had marked insecticidal or repellent properties to the particular species of insect on which it was tested; but, in the absence of any information on the reproducibility and degree of variation of the results, it does not seem possible to assess whether the difference between the categories listed is really significant. A critical study of the test methods employed would add greatly to the value of the results. It is stated that the data are presented in the belief that they may prove useful to workers engaged in the development of new insecticides or in the study of the relation of chemical structure to insecticidal activity, and this may well prove to be so.

Medicine in the Atomic Age

The November issue of *Medicine Illustrated* consists of a number of articles under two general headings: peaceful uses of atomic energy; and atomic warfare, medical aspects. Prof. J. Rotblat describes with admirable clarity for the layman the nature and production of radioisotopes, and Mr. N. Veall has the hard task of selecting examples of how these isotopes are used in investigation and diagnosis. Drs. R. Bodley Scott and R. M. Cunningham are clear in describing the uses of phosphorus-32 and iodine-131 for therapy, and Dr. R. J. Walton surveys the therapeutic uses of other radionuclides. Mr. H. Dunster, as a health physicist, explains how personal protection is achieved and how contaminated waste can be disposed of. Prof. K. Mather ends a good collection of papers with an admirable survey of the genetical price of radiation. On the medical aspects of atomic warfare, the authors are on a much 'stickier wicket' and, like the most skilled performers in such conditions, are guilty of many lapses from orthodoxy. However, few would dare to predict the future in this field, so that in general any stimulus to thought is good. From an illustrated journal one would have expected more pictures and less script, and surprisingly many of the illustrations are very poor; by far and away the best is an abstract from a case report by L. H. Hemplemann with coloured plates from *Medical Radiography and Photography*.

Aerosurvey by Photography

Mr. A. D. Dodds-Parker, Parliamentary Under-Secretary of State for Commonwealth Relations, will

open an exhibition of photography in aerial survey work at the Kodak Gallery, 184 Regent Street, London, W.1, on January 10. The exhibition shows something of the activities of Hunting Aerosurveys, Ltd., Hunting Geophysics, Ltd., and Aerofilms, Ltd. Hunting Aerosurveys, Ltd., are concerned mainly with stereoscopic photography for map-making; Hunting Geophysics, Ltd., engage in mineral prospecting; and Aerofilms, Ltd., specialize in 'oblique' shots of towns, well-known land-marks and industrial projects. The exhibition will be open to the public during January 11–29 (Mondays to Fridays, 9.30 a.m.–5 p.m.; Saturdays, 9.30–11.30 a.m.); admission is free.

University of London: Appointments

THE following appointments in the University of London have been announced: Mr. G. A. Barnard, reader in mathematical statistics in the Imperial College of Science and Technology, to the University chair of statistics tenable at that College; Prof. Arnold Tustin, professor of electrical engineering in the University of Birmingham, to the University chair of heavy electrical engineering tenable at the Imperial College of Science and Technology; Dr. Paul Fatt, senior research fellow in physiology at the Australian National University, Canberra, to the University readership in biophysics tenable at University College. The title of professor of zoology in the University has been conferred on Dr. G. P. Wells in respect of his post at University College, London.

University of London: Awards

THE following awards made by the University of London have been announced: *I.C.I. Fellowships*, each of the value of £750 per annum, and tenable in the first instance for three years: D. R. Bland, for research in theoretical mechanics, in particular in plasticity and heat transfer, at the Imperial College of Science and Technology; Dr. G. W. H. Cheeseman, for research on the chemistry of organic nitrites and nitrates, at Queen Elizabeth College; Dr. G. L. Sewell, for research on the fundamental theory of condensed matter, at the Imperial College of Science and Technology; Dr. G. H. A. Cole, for research in the field of ionic physics, at University College; Dr. R. Pettit, for a study of conjugated organic molecules containing one or more hetero atoms, at Queen Mary College; *Turner and Newall Research Fellowship*, of the value of £750 per annum, and tenable in the first instance for three years, to Dr. T. J. Lewis, for research on the electrical strength of pure liquids, at Queen Mary College.

Announcements

PROF. ROBERT CRUICKSHANK, professor of bacteriology in St. Mary's Hospital Medical School, London, has been appointed principal of the Wright–Fleming Institute of Microbiology at the School in succession to Sir Alexander Fleming, who has retired.

DR. REGINALD CHILD has been appointed director of the Tea Research Institute of East Africa in succession to Dr. T. Eden, who retired in June. Dr. Child has been senior chemist of the Institute since its inception in 1951 (see *Nature*, **169**, 959; 1952).

THE Thomas Young Oration for 1955 of the Physical Society will be delivered by Dr. W. S. Stiles (National Physical Laboratory) on February 25, in the lecture theatre, Science Museum, London, S.W.7, at 5 p.m.; Dr. Stiles will speak on "The Basic Data of Colour-matching and Some Related Aspects of Visual Theory".

THE spring meeting of the Physical Society will be held at the Atomic Energy Research Establishment, Harwell, during March 31–April 2. The subject of the meeting will be "Neutron Physics and Energy Levels". Accommodation can be arranged at Lincoln College, Oxford, provided notification is received at A.E.R.E., Harwell, not later than January 31. Application forms to attend the meeting can be obtained from the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

A PAMPHLET on selenium, by R. Ashton, E. G. Hill and D. Neville-Jones (London: H.M.S.O.; 1*s*. 6*d*. net), gives a concise but very informative survey of the sources, production and uses of selenium, and includes the use of selenium in the glass industry and selenium rectifiers (as an alternative to germanium). There is at present a shortage of selenium, and possible alternatives are discussed.

A TECHNICAL data sheet, of thirty-four pages, on piperidine has been issued by Robinson Bros., Ltd., of Ryders Green, West Bromwich, Staffs. It contains a survey of the physical and chemical properties of piperidine and descriptions of reactions in which it is used, with complete references to the literature, and is likely to be of service in chemical laboratories. In addition to pure piperidine, the commercial varieties are considered. The document is very useful in that it contains information not otherwise easily available.

A SYMPOSIUM on "The Protection of Structural Steel", organized by the Corrosion Group of the Society of Chemical Industry, will be held in London in the lecture theatre of the Institution of Civil Engineers during March 31–April 1. Those contributing papers will be from Belgium, France, Holland, Sweden and the United States, as well as Great Britain, and accounts will be given of practical experience and of research with protective coatings. Further information can be obtained from the honorary secretary of the Group, S. C. Britton, Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex.

A SERIES of seven lectures on "The Shape of Work to Come" is being given at St. Anne's House, Soho, on Thursdays at 6.30 p.m., beginning January 13. The speakers will include the Right Hon. L. J. Edwards, on the philosophy of work; Mr. J. R. Gass (Intelligence Division, Department of Scientific and Industrial Research), on the implications of automatic production; Dr. R. W. Revans (formerly director of education, National Coal Board), on the scale and structure of industry; Mr. A. Healey (British Institute of Management), on the significance of industrial psychology and welfare; Dr. M. M. Finiston (Atomic Energy Research Establishment, Harwell), on the transformation of society by the coming of atomic power; Prof. Michael P. [illegible]garty (professor of industrial relations, University of Wales), on the true end of man and his work. Admission is by ticket only, obtainable from the Secretary, St. Anne's House, 57 Dean Street, Shaftesbury Avenue, London, W.1; single lectures, 2*s*. (house members 1*s*. 6*d*.); season tickets, 12*s*. 6*d*. (house members 10*s*.).

RESEARCH AND INDUSTRIAL PRODUCTIVITY

DURING November 22–25, the Department of Scientific and Industrial Research, in association with the British Productivity Council, held a working conference on "Research and Industrial Productivity". At its opening luncheon, the Lord President of the Council, Lord Salisbury, stated the national problem, that unless we can work to better advantage, making full use of the knowledge which science can provide, Britain will be unable to maintain its social services and exercise its proper influence in world affairs. The conference itself was directed both to the considerations which determine whether and how quickly a scientific or technological advance can be successfully introduced into industry, and also to the scientific studies by which management and work can be improved so as to yield a higher productivity. The British Productivity Council and many industrial leaders participated, but the body of the conference came mainly from the councils and staffs of research associations, nationalized industries, and a few from government departments.

At the first session, Sir Ben Lockspeiser recalled that King George V, when Prince of Wales, had described the problem in opening the National Physical Laboratory half a century ago. Since then, Sir Ben said, we have developed a greater social conscience and Britain's share in world trade has diminished. To maintain and increase our living standards we must both expand our production and increase its efficiency. We must particularly seek increased efficiency with a minimum of capital investment, because this is a charge on productivity. Similar economy is essential in raw materials. He instanced selenium, where electric and electronic equipment may have a higher claim than brighter milk-bottles. Nor is there a reservoir of technical talent or of labour. Technologists must be used sparingly. The partially or fully automatic factory may go far in meeting labour shortage.

Sir Ewart Smith, vice-chairman (now chairman) of the British Productivity Council, showed that, in spite of recent favourable trends, the rate of increase in productivity in Britain has been, for a considerable period, consistently less than in the United States, although at one time the rates had been the same. We ought to aim at an increase of 10 per cent per annum in the hope that few would fall below 5 per cent and many would achieve 7 or 8 per cent with a reasonable number attaining 10 per cent. He analysed the functions of research, management and operational study. He indicated that the research outlook is essentially that which would provide the information and principles on which management decisions should be based and by which improved practice could be instituted on the shop floor. The advantages of automatic operation must be balanced against maintenance work and first cost, but there is the opportunity of transferring labour from routine to interesting work. Although research associations and such bodies cannot do industry's job, yet they can and must provide the basic information, the principles and the encouragement to hasten the industrial revolution which, as Sir Ben had said, is now on the way.

In opening the discussion, Dr. S. Whitehead, chairman of the Committee of Directors of Research Associations, said that, additional to those research associations which have operational departments, many others decentralize such work. He instanced certain difficulties, such as in making an economic case for change and capital investment, workers' co-operation in research, natural inertia and over-indulgence in pride in past achievement and standardization. Nevertheless, research associations must sincerely accept the tasks put by Sir Ben and Sir Ewart both by making the necessary studies and in producing a favourable industrial climate of opinion. Dr. B. K. Blount, deputy secretary of the Department of Scientific and Industrial Research, remarked that the stations of the Department serve many industries and deal with problems of national well-being. He gave instances to show their insistence on practical application to essential needs. In addition, the Department has central services for studying efficiency and the human element, and to help in all kinds of operational research and information problems. The general discussion turned on the best strategy of approach to industry, and specific problems such as local redundancy.

In a session on materials, Mr. D. A. Oliver, director of the B.S.A. Group Research Centre, said he thought that private enterprise could not unaided exploit mineral resources fully on a long-term plan owing to shortage of risk capital and man-power, insufficient technical resources, lack of information and the uncertainty of world conditions. He proposed that the government should co-operate by the setting up of a minerals advisory bureau, the continuous study of consumer demand and the provision of a national mineral-dressing and process metallurgy laboratory. Although the type of assistance proposed was agreed in the discussion, there were differences as to the mechanism and the institutions which should be responsible. Prof. S. Zuckerman stressed the desirability of living on income rather than capital. Synthetics do not usually replace natural materials, he said: they satisfy new needs and often make large demands upon non-renewable resources such as coal and oil. Conversely, synthesis can shift the burden to renewable resources such as cellulose. If photosynthesis could be understood and made efficient, solar energy and renewable organisms would be much better than chemical factories. These considerations often conflict with short-term profitability, but we must strive towards the best balance, in which both productivity per acre and per man are important. In the discussion the effort was mentioned that has already been made to reduce waste and recover used materials, though the present economic value of recovery does not always represent its ultimate value. Pest destruction could give an immediate saving, and advance in fertilization would increase yield per acre; but in Prof. Zuckerman's view there is a long way to go.

Mr. K. T. Spencer, chief scientific adviser, Ministry of Fuel and Power, recalled that the industrial progress of Britain has been based on cheap coal. An expanded and competitive industrialization demands

more fuel. At best, nuclear energy will leave for ten years or more an increasing gap between demand and supply. No spectacular increase in coal production has followed mechanization, and the quality has deteriorated. We have provided for increased use of oil; but greater dependence on imports is ultimately unsatisfactory. We must, therefore, use fuel more efficiently. Railway electrification could save 13 million tons of large coal at the cost of 5 million tons of poor coal. The domestic open fire is condemned anyhow by pollution. Improvements in fuel efficiency have been achieved in collieries, in the ceramics, the iron and steel and the laundry industries; but comparisons show that there is great room for improvement in industry as a whole by the intelligent use of existing data. Research associations could give a lead to industry in this and several have done so; but industry must respond to advice on this central essential problem irrespective of local incentives, since some industries are large coal users but have a low proportionate fuel cost.

Dr. W. A. MacFarlane, director of the National Industrial Fuel Efficiency Service, described the National Fuel Efficiency Service, which has taken over and expanded the service of the Ministry of Fuel and Power. The Service finds sources of waste, improves operation, makes detailed inspections and full heat and power surveys. He stressed the importance of data on low-pressure steam. Mr. O. F. Thompson's paper dealt with economic factors in the provision of low-cost energy in the future. Research was urged on economic forecasting, capital resources and availability, and the effect of taxation. In the discussion, attention was directed to what has been done in collieries, the advantages of pithead electrification, and the reduction between 1920 and 1938 from 1,550 tons to 670 tons needed to generate a million kWh.; since 1938 the firing coal used for ceramics has fallen from nearly 1·25 to 0·4 million tons. Economy is possible in the labour used in obtaining and using fuel. Although water-power, wind-power, terrestrial heat and solar radiation might make no great contribution, they should be used. There is no doubt as to the informed interest in fuel efficiency.

Prof. C. F. Carter, of The Queen's University, Belfast, urged examination of the business hurdles which innovations must surmount—capital investment and risk, the amount and period of profitability, the uncertainties of markets and supplies, the interval required to achieve success. He believes that nowadays managements are less willing to take risks; but, conversely, with full employment and an inflationary tendency, the risks are less. Dr. R. M. Lodge, research manager of British Nylon Spinners, Ltd., in a paper on the economic factors in the planning of research, referred to economy in the use of scientists, the modern growth of team-work, freedom of atmosphere and the minimum and maximum of expenditure, which are related to the amount of development work. This is much more costly than research and should be more carefully planned, bearing in mind production and sales. Mr. A. H. Wilson, director of research and development, Courtaulds, Ltd., in a paper on the economics of re-equipment, dealt with some of the questions raised by Prof. Carter and discussed the economic effect of discarded plant when changing an existing industry as compared with founding a new industry. Dr. F. M. Lea, director of the Building Research Station, Department of Scientific and Industrial Research, illustrated in the building industry, where there are few large firms and not much capital, the influence of new machines (such as the tower crane) and methods on productivity and the organization to secure it. He showed how these considerations have determined the work of the Building Research Station. Mr. R. T. Eddison, of the British Iron and Steel Research Association, used the example of the handling and transport of iron ore to show how the best compromise can be reached in choosing a method of working, when several different resources are needed which are differently, perhaps oppositely, affected by changes and where the simple criterion of cost might need some qualification. The various discussions on these papers agreed as to the necessity of economic appraisal, but there was divergence as to how it should be done. Similarly, the planning of research against the background of application was admitted, but not the detailed methods: the mention of sponsored research provoked discordance. The opinion was expressed that large concerns in the United States are no more venturesome than British industry. It is clear that the study of the effect of innovation upon production and operation is widespread.

The next two sessions were devoted to the human factor. Mr. R. M. Currie, head of the Central Work Study Department, Imperial Chemical Industries, Ltd., stressed the need for research into work study, which he said is an important tool in management and also is based on the same principles as scientific research; but its application must be direct and speedy. Mr. N. Fleming, chairman and managing director of Associated Industrial Consultants, Ltd., added the further management tools of cost-control and production-planning and control. He thought great improvements could be secured by existing methods, provided co-operation between management and workers is achieved. Dr. C. B. Frisby, director of the National Institute of Industrial Psychology, dealt with the adaptation of equipment and work organization to the anatomical and physiological characteristics of the worker. This leads to psychophysical features which affect the skill of the worker. Lastly, there are psychological aspects which influence the worker's attitude to his task and the satisfaction he gains, and here the relations between workers must be considered.

The two papers from trade union representatives showed some difference of attitude. Mr. L. T. Wright, general secretary, Amalgamated Weavers Association, believes that productivity is primarily the function of management, which must also convince the workers that they will benefit as human beings from changes: general full employment is not an answer to particular local redundancy. Although Mr. Crawford, chairman of the National Union of Boot and Shoe Operatives, was as emphatic on a proper appeal to workers' natural human qualities, he considered that they can aid management both in planning and in encouraging a favourable response. He examined incentive schemes, rate-fixing and work-organization and gave examples of successful schemes which have been carefully planned and judiciously introduced to the workers. The discussion indicated the general interest in work study, and that the same principles are applicable in many other branches of human activity. Mr. Crawford's opinion that workers would respond to well-conceived and well-expressed ideas seemed to be accepted.

The summing-up of the conference was by Dr. A. King (D.S.I.R.), Dr. F. C. Toy (Shirley Institute),

Mr. F. Courtney Harwood (Launderers' Research Association), Mr. S. H. Clarke (Fire Research, D.S.I.R.), the Hon. L. O. Russell (Institute of Management) and Sir Thomas Hutton (Productivity Council). The conference had shown how many resources are available for improving productivity and meeting its technical, its economic and its human problems. All these resources are not everywhere known or used. To overcome this there are two main national agencies. The British Productivity Council, with its decentralized regional organization and circuit system, endeavours to bring management and workers together in every main industrial area, making use of modern methods of presentation. The second agency is provided by the research associations and the Department of Scientific and Industrial Research with its stations. These bodies have valuable contacts with industry since they impinge directly on the particular industrial sectors of which they have expert knowledge. They have already done a great deal and are converted to the objects of the conference. Nevertheless, their structure, especially that of the research associations, permits them to do more; the value of the conference will depend upon whether it succeeded in establishing that interest in scientific and technological research should not limit the effort to convert industry as a whole to the principles which those attending the conference accepted.

X-RAY APPARATUS AND ASSOCIATED TECHNIQUES

EXHIBITION IN LONDON

As in previous years, an exhibition of X-ray apparatus was arranged in conjunction with the annual congress of the British Institute of Radiology, and was held at the Royal Horticultural Hall, London, during November 23–26. The majority of the exhibits were concerned with medical applications, both diagnostic and therapeutic, but industrial and scientific instruments were also represented.

Perhaps the most striking feature of modern electronic components and instruments is the way in which improvements in design and in materials have made possible reductions in size and in power consumption. This was well exemplified by much of the X-ray equipment on show. The increased use of oil-immersed components has resulted in compact single-unit power supplies for X-ray tubes, some of them incorporating series triode control valves which permit instantaneous high-tension switching as well as current and voltage stabilization. Another advance in this direction was represented by new oil-immersed high-tension rectifiers the filaments of which consist of thoriated tungsten with a power consumption less than one-third of that of pure tungsten filaments. Another interesting power supply includes a flywheel energy-storage generator which makes it possible to obtain a short-duration X-ray burst of very high intensity without drawing a heavy load from the mains supply.

X-ray tubes themselves have become more mobile; oil-insulated industrial tubes permit underwater radiography, and medical diagnostic and therapeutic tubes are mounted on cradles or above tilting tables which allow them and the patients to be moved automatically or with finger-tip control. Higher intensities are provided by the large range of rotating anode tubes. Another approach to the intensity problem in radiography is provided by the development of more-sensitive detecting devices. A new X-ray film is claimed to be 50 per cent faster than any previous type. Of even greater interest, perhaps, are the new image amplifiers, several examples of which were on show. In these tubes X-ray energy is first converted into light energy by a thin fluorescent screen, in contact with which is a photoelectric surface which, in turn, converts the light into electron emission. The electrons are accelerated by a high potential and focused on a final output screen. By these means the limit of brightness for threshold vision is reduced by a factor of 10 : 1, while the exposure time in fluorophotography is in the ratio of 200 : 1 as compared with the image produced on a normal fluoroscopic screen.

Artificial radioisotopes are becoming of ever-increasing importance both in therapy and in radiography. This fact was reflected in the many instruments on show for the handling and the detection and measurement of high-activity sources. The measuring instruments exhibited ranged from a simple 'nurse-proof' radiation monitor to fully automatic equipment capable of measuring the activities of up to 425 planchet-mounted samples to any desired degree of accuracy without any intervention from a human operator, the results being printed by the machine.

In X-ray therapy the deleterious effects of radiation on healthy tissue are now guarded against, so far as possible, by arrangements of ingenious geometry such as those employed in arc irradiation and in moving-beam methods. A new possible way of reducing radiation burns, which may be of great potential importance, is the discovery of the inhibitory effect of cortisone injections on acute X-ray damage to animal tissue. Discoveries like the last, together with apparatus as yet in the experimental stage, were demonstrated in a small scientific section at the exhibition. In general, the main commercial part of the exhibition demonstrated that the X-ray industry is quick in developing new ideas to a production stage.

U. W. Arndt

THE AGE OF THE UNIVERSE

The Philosophy of Science Group of the British Society for the History of Science last year offered a prize for "the best essay on: What is the logical and scientific status of the concept of the temporal origin and age of the universe?" Twenty-six essays were submitted, and a selection of six of these is published as the major portion of the November issue of the *British Journal for the Philosophy of Science*. The subject is considered from various points of view, the competitors having been asked to "clarify the logical, theoretical and observational aspects of the idea of assigning a quantitative age to the Universe". Naturally the essays vary in the distribution of emphasis between these aspects, and in those published the evidence most relied on ranges from the almost entirely logical to the equally one-sided observational kind. The value of the publication as a whole is thus greatly enhanced, and one receives the impression that the editors have made

a wise choice of contributions for the enlightenment of those who wish to obtain as comprehensive a view as possible of the whole problem.

The particular solutions arrived at, which are quite properly advanced with caution, differ considerably; but these are of less significance than the arguments that lead up to them. The essays should therefore be read in full if the greatest benefit is to be derived, but an indication of the conclusions may be of some interest. M. Scriven (Minnesota), from epistemological reasoning, concludes that "no verifiable claim can be made either that the Universe has a finite age or that it has not. We may still believe that there is a difference between these claims: but the difference is one that is not within the power of science to determine, nor will it ever be". J. T. Davies (London) provisionally accepts the age (about 4×10^9 years) given by linear extrapolation from the nebular recession hypothesis as being "the simplest interpretation of the observations and as being in excellent numerical accord with the age from independent investigations" of particular constituents of the universe. E. J. Öpik (Armagh) accepts the agreement (in general order of magnitude) of the ages given by various phenomena as suggesting an age not exceeding 6×10^9 years for the universe "in its present form and content". G. J. Whitrow (London) also lays stress on this agreement, which "strongly suggests that the universe has a finite age of some 4,000 million years". R. Schlegel (Michigan) prefers the view that the universe is "atemporal"—that is, the concept of time is inapplicable to it as a whole. He distinguishes this from the view that the age of the universe is infinite, for this would be a particular solution for a universe to which the time concept is applicable. B. Abramenko (Mannheim), though admitting that conclusions must be based on observational evidence which at present is inadequate to settle the matter finally, favours the view that time, like space, is curved, so that physical processes occur in cycles. There is then no such thing as the age of the universe as a whole, and the indications of age from the various phenomena relate to the length of one cycle in the infinite succession of cycles. Unlike most of the writers, however, he attaches more significance to the differences between these indications than to their agreement.

All the more prominent systems of cosmology—general relativity, kinematical relativity, the 'steady state' theory involving continuous creation—are given some attention, but it is noteworthy that none of the essayists writes specifically from the point of view of any of them; indeed, the objective character of the approach throughout is a praiseworthy feature of the collection. One point, however, would repay further elucidation. More than one writer is evidently under the impression that, in the 'steady state' theory, nebulæ are assumed continually to pass out of the region of possible observation, at a finite distance from the observer, through attaining and surpassing the velocity of light. Recent correspondence in *The Observatory* (**74**, 172; August 1954), however, suggests that this may be a misreading, notwithstanding that it is the apparent purport of the papers in which the theory was originally presented, and that in fact the theory assumes that the region observable in principle is infinite in extent, no nebula ever disappearing from it. It is very desirable that some clear statement on this point should be made by the authors of the theory, to prevent further misunderstanding.

ROYAL OBSERVATORY, CAPE OF GOOD HOPE

REPORT FOR 1953

THE report for 1953 of the Royal Observatory, Cape of Good Hope*, shows that an extensive programme of painting and repairs to the Observatory has been carried out, and dilapidations which accumulated during the war period have been practically overcome. Redecorations, externally and internally, have been effected in a number of buildings and at the time of writing the report only the new office buildings, a residence and a few other minor items required attention. In addition, electrical work has been carried out in some of the residences, a few extra trees have been planted, and it is hoped that a new hedge planted near the entrance gates will eventually provide some protection from the prevailing south-east wind.

The reversible transit circle has been in regular use and has required little special maintenance; observations were made with it on 155 days, 187 evenings and 113 mornings. The fitting of modern roller and thrust bearings to the declination axis of the Victoria telescope was completed in January, and the new cell made by Messrs. Cox, Hargreaves and Thomson for the 24-in. lens was then installed; this cell has resulted in a marked improvement in the performance of the lens. A number of alterations have been made in other ways, among which may be mentioned the replacement of the old windscreen by a new all-canvas screen which allows observations to be made within a few degrees of the horizon instead of 30° as with the previous arrangement. The telescope was used on fifty-seven nights for photoelectric observations, sixty-one nights for direct photography, and the astrometric camera that is mounted on it on forty-two nights. The astrographic telescope, which was in continuous service, was used on one hundred and sixty-five nights for photoelectric photometry, on five nights for direct photography and on forty-eight nights for photography with the photometric cameras mounted on it. This telescope, while still behaving fairly well in spite of its age, requires a thorough overhaul in its drive and clamping mechanism, and, in addition, the axles and bearings of the wheels carrying the dome are badly worn and will shortly need renewing.

The 7-in. telescope and the tower telescope have been used for observing occultations, and the former has also been used for visitors. The tower telescope is not in good condition as the old stand is unsteady, and the lens requires repolishing. The 6-in. telescope has been in regular use for observing long-period variable stars, and has also been used for visitors and for observing occultations. The photoheliograph has been used to take two photographs daily of the sun. The camera is in fair condition; but the stand is old, the polar axis unsteady and the clock drive unreliable. A few minor adjustments and alterations were necessary on the photometric cameras mounted on the astrographic telescope in November 1952, and the timing device was completed and brought into use. The astrometric (or wide-angle lens) camera which was dismounted from the astrographic telescope in 1952 was mounted on the Victorian telescope

* Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the Year 1953. Pp. 11. (Cape of Good Hope: Royal Observatory, 1954.)

when the work on the declination axis had been completed, and was used on forty-two nights during 1953.

Many other matters are dealt with under the following headings: observations and reductions; stellar photometry; Radcliffe section; meteorological observations; publication of results; personnel establishment; and miscellaneous. Under the first of these is included an account of the parallax programme, and, although the observations for the main part of the parallax programme were completed in 1951, a few extra plates were needed to complete the determination of the proper motions in declination. Since the start of the programme in 1926, the parallaxes of 1,792 stars have been determined, while 3,508 plates are waiting to be measured for parallax and a few hundred for proper motion. Parallaxes were derived for thirty-two stars, none of which had a parallax previously derived at the Cape. Under the heading of stellar photometry is included work on bright stars, and reference is made in this to the new bright star programme which includes all stars in the Yale Bright Star Catalogue between dec. $-4°$ and $-64°$, together with a number of fainter stars from the radial velocity and parallax lists. Observations are being made in two colours with the photoelectric photometer attached to the astrographic refractor. The stars used in the previous programme, that is, those brighter than *HR* 5·0, are used as standards, observations being made, as previously, at 30° zenith distance. Under the heading of miscellaneous, Dr. R. H. Stoy, H.M. Astronomer at the Cape, refers to his two short trips overseas, the first to attend the conference on the co-ordination of galactic research, which was held at Groningen, and the second to attend two conferences in the United States, one being on photoelectric photometry, and the other on astrometry. "These three conferences," remarks Dr. Stoy, "relating as they did directly to the work of this Observatory, proved to be very helpful in suggesting the most useful programmes for future work."

THE FUNCTION OF HYDROXYPROLINE IN COLLAGENS

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Introduction

THE degree of intermolecular and interfibrillar stability of collagen to hydrothermal influence, that is, its resistance to heat in the fully hydrated state, is most conveniently measured by the temperature at which instantaneous shrinkage of the collagen fibres takes place (thermal shrinkage). In earlier investigations, it was found that the shrinkage temperature, T_s, of collagen from fish skin (Teleostei) is much lower than that of mammalian collagen, specimens of cod fish and of bovine skin mainly being investigated. Thus, native collagen of cod fish skin shrinks at temperatures of about 40° C.[1,2], when freely suspended, whereas bovine skin requires temperatures of about 65° C. For collagen of the skin of eel and freshwater fishes from Swedish lakes, T_s was found to be in the range 55–57° C.[3]. Regarding the hydrothermal stability of the corium, the fishes form two distinct groups: (1) the cold- and deep-water fishes for which T_s of their skins is in the range 37–45° C.; and (2) the warm- and surface-water fishes with values of 50–57° C.[3]. During the past fifteen years, the shrinkage temperatures of a large number of skins from various species of salt- and fresh-water fishes in Swedish waters have been determined[1–7]. Independently, Takahashi and Tanaka[8] have determined the shrinkage temperature of skin collagen from a great number of fishes in Japanese waters, and they also find the values to fall into two distinct temperature-ranges.

Earlier Findings

It was suggested in the early work on cod fish collagen[1,2,4], at a time when data for the amino-acid composition of mammalian collagen were far from being quantitative and no reliable analysis of the amino-acid make-up of fish collagens was available, that the marked difference in hydrothermal stability of bovine skin and cod-fish skin was probably not due to different chemical composition (amino-acids) but rather was a problem of different intermolecular stabilization of the two main classes of collagen. Thus, in the final analysis, it should be a question of molecular architecture and organization.

The following differences in chemical behaviour of the collagens of skins of mammals and teleosts (*Gadus*) have been found earlier[1–7,9–13]. Collagen of fish skin is more easily gelatinized than that of mammalian skin. The former is also more extensively degraded and solubilized by acids and alkalis and by trypsin than native bovine skin[1,2], which is practically unattacked by trypsin[13,14]. Thermal denaturation of fish collagen does not increase its reactivity towards large molecules, mainly interacting with proteins by means of co-ordinate valency forces (hydrogen bonding), for example, vegetable tannins, while the fixation of these agents by collagen of bovine origin is drastically increased by denaturation of the protein[4–7]. The reactivity of agents principally reacting with proteins by means of electrovalency is practically identical for both types of collagen, native as well as denaturated[4–7].

Irreversibly fixed polyacids show distinctly different effects on the two types of collagen. The bovine type is not markedly changed, and is in some respects stabilized by these agents, whereas cod skin is practically destroyed by irreversible uptake of the polyacids, T_s is much decreased and the fibre strength is completely lost[9]. Additional characterization has been obtained from investigations of the effect of anionic detergents such as sodium dodecyl sulphate in 5 per cent aqueous solution. Cod skin was largely solubilized, whereas no permanent alteration of bovine skin was found in these treatments. The unifunctional, non-swelling naphthalene-β-sulphonic acid and polymetaphosphoric acids show the same differences in their action on the two forms of collagen[10].

In view of these observations and the fact that the acid- and alkali-binding capacities of the two types of collagen were identical, it was suggested that the difference between the bovine and teleost (cod fish) collagens should be principally one of molecular organization, the low degree of stability of the fish-skin collagen being ascribed to a less developed

intermolecular cross-linking of the protein chains, compared to bovine collagen[1-3]. The titration curves also showed close similarity, only with a slight deviation of the curve in the *p*H range 3–9, pointing to more easily discharged ionic groups (salt links) in the case of fish collagen[10].

In view of these findings, the following working hypothesis of the structural organization was advanced. Mammalian-skin collagen, with its intertwining fibre bundles, is mainly stabilized by means of hydrogen-bond bridges between laterally located keto-imide groups. Salt links of electrostatic nature probably supplement these primary cohesive forces. In fish-skin collagen, with parallel grouped layers without any marked interlacing of fibre bundles, on the other hand, the low degree of stabilization of the structure may be accounted for by the assumption that the hydrogen bonding is only weakly developed, electrovalent cross-linking being responsible for a great deal of the structural cohesion.

This finding that the irreversible inactivation of the ionic groups of fish collagen by means of non-swelling agents, specific for these groups (eliminating the electrovalent cross-links), leads to a drastic lowering of the stability and mechanical strength of the fibres would then be due to the fact that these salt links are to a great extent responsible for the cross-linking, hydrogen bonding being less developed. On the other hand, the structural properties of mammalian collagen, mainly stabilized by cross-links of the hydrogen-bond type, are not materially impaired by the elimination of the salt links by discharge, since the ionic interchain forces contribute only slightly to the molecular cohesion, the dominant cross-links being of the hydrogen-bond type, which are not involved in the fixation of the agents specific for electrovalent protein groups.

This view is supported by some additional findings: (1) The general properties and the reactivity of fish-skin collagen resemble those of bovine collagen which has been pretreated with lyotropic agents, such as concentrated solutions of urea, the main effect of which is to rupture interchain links of the type of hydrogen bonds and make sites of reaction available in the protein[4]; (2) Nutting and Borasky[15] found the electron-microscopic picture of shark-skin collagen to be similar to that of bovine collagen which had been degraded by prolonged alkali treatment (liming).

Amino-acid Composition

Further progress became feasible with the advent of complete data on the amino-acid composition of mammalian collagen[16] and of the corresponding data for fish collagen[17]. The main difference between collagen of mammals and teleosts is the low content of hydroxyproline (9 per cent) of fish-skin collagen (halibut[18], shark[19]) compared to the figure of 14 per cent for bovine collagen, apart from minor divergences in amino-acids present in small amounts, such as serine, threonine and methionine[17]. Hence, the possibility of the hydroxy group of the hydroxyproline residue being involved in the intermolecular linking of collagen is obvious[3]. The original view of the less-developed intermolecular hydrogen bonding on the peptide links of fish collagen may then have to be modified, with due attention to the possible function of the hydroxy groups in the interchain linking[3].

In view of the different hydrothermal stability of skins of warm- and cold-water fishes, their contents of hydroxyproline and proline should be of interest, particularly for ascertaining whether there exists any relation between the contents of pyrrolidine residues and the T_s of the collagens. The possible function of the hydroxyproline residue for stabilizing collagen has been suggested by Borasky[19] and the present author[3,20]. In a preliminary note on the hydroxyproline contents of mammalian collagen and of the two types of teleost collagens, such an interdependence was reported[3]. This finding has been independently verified by Takahashi[21]. On investigating skins of some fifty-odd species of fishes, Takahashi[21] found 7–9 per cent hydroxyproline in skins of cold-water fishes, with T_s in the range 34–44° C. The great majority of species contained 8 per cent. The corresponding values of the skins of warm-water fishes, with T_s 50–58° C., were 10–12 per cent. The figures for bovine hide and gelatin were 12·5 and 13·4 per cent, respectively. The lowest value of hydroxyproline, 7·0 per cent, was found for the skin of the rock-fish (*Sebastodes baramenuke*), which also showed the lowest T_s ever recorded for collagens, namely, 33–34° C. The highest values of T_s and hydroxyproline were recorded for the skin of the carp (*Cyprinus carpio*) with 57° C. and 11·6 per cent, respectively[21].

The available data on the content of hydroxyproline have been obtained by the method of Neuman and Logan[18]. The accuracy and reproducibility of this method is not as great as could be desired, and since indirect values only are obtained by this technique, a direct estimation of this imino-acid was imperative. By a combination of the Moore–Stein chromatographic procedures on columns of starch[22-25] and on 'Dowex-50'[25,26], according to the modification of Åqvist[27], the contents of hydroxyproline and proline of collagens of skins from mammals and from representative species of the two main groups of Teleostei have been estimated by Dr. S. Åqvist.

Materials and Methods

Isoelectric collagen of calf-skin pelt (lightly limed for unhairing) represented the mammalian collagen. Specimens of skins of cod fish (*Gadus morrhua*) and of pike (*Esox lucius*) were selected as typical cold-water and warm-water fishes. The fish skins were not subjected to any alkali treatment. After mechanical removal of scales, adipose tissue and other non-dermal matter, the fresh skins were soaked for 24 hr. in a 10 per cent solution of sodium chloride and saturated with toluene, at 5° C., in order to remove globular and other accessory proteins. The skins were washed and drummed in cold water until free from chloride ions. The acetone-dehydrated skins were then extracted with petroleum ether and finally acetone-dehydrated. The T_s values of the skins were determined by the conventional method on freely suspended strips of both fresh and purified skins. Identical T_s values were found. Six determinations were carried out on each skin. The samples were taken from different parts of the skin, cut in dorsal and ventral directions, from six specimens. The acid-binding capacity was determined indirectly by estimating the acid removed by 500 mgm. collagen in the form of small cubes, from 10·0 ml. of 0·1 *M* hydrochloric acid, one-molar in sodium chloride, upon 4 hr. shaking, titrating the residual solution to *p*H 5.

The estimation of proline and hydroxyproline was carried out on 500 mgm. samples of skin substance,

Table 1. General Characteristics of Collagens

No.	Type of skin	T_s in °C.	Per cent total nitrogen on ash- and fat-free dry substance	Per cent ash	Acid-binding capacity in m*M* hydrochloric acid/gm. collagen
1	Cod fish (*Gadus morrhua*)	40	18·3	0·8	0·92
2	Pike (*Esox lucius*)	55	18·4	1·0	0·93
3	Calf (*Bos taurus*)	65	18·3	0·05	0·90

which was refluxed with 6 *M* hydrochloric acid for 36 hr. The first separation was on a column (300 mm. × 80 mm.) of a special starch. The column was washed with 8 litres of propanol–hydrochloric acid (1 : 1) and finally equilibrated with a solution of propanol–0·5 *M* hydrochloric acid (2 : 1). Portions of 200 mgm. protein were applied. This solution was made 0·5 *M* in hydrochloric acid and the double volume of propanol added. Hourly fractions were collected with the aid of a time-controlled fraction collector. For localization of the position and for identification of the amino-acids, the photometric ninhydrin method of Moore and Stein[22,23] was applied to 0·05 ml. of each fraction. The fractions were also located on a paper chromatogram, which is particularly useful for examination of overlapping fractions of hydroxyproline. The proline came out in fractions essentially pure after collecting 4 litres of eluate, and the hydroxyproline fractions after running 6 litres. The volume of the collected fractions of each amino-acid was about 800 ml. The hydroxyproline fractions were contaminated with threonine, and contained also smaller amounts of alanine, glutamic and aspartic acids. Therefore, a re-separation was necessary for hydroxyproline, and also for the proline in order to remove non-protein nitrogen (ammonia), due to contamination during the various operations. The collected fractions were evaporated *in vacuo* and dissolved in *M* hydrochloric acid. The final separation was on a column of 'Dowex-50', using the 'colloidal' type of 250–500 mesh, operated on the hydrogen cycle. The column was 20 mm. × 800 mm. *M* hydrochloric acid was used as eluting solvent. The resolving power of this column was excellent. Pure fractions of proline and hydroxyproline were collected in a comparatively small volume. The contents of the prolines were estimated by the micro-Kjeldahl method, since no satisfactory colorimetric methods for the prolines are available.

Data on the general characterization of the three types of skin collagen are given in Table 1. The results of the imino-acid analysis are shown in Table 2.

Discussion

General aspects. The collagen group of proteins is characterized by the prominence of proline and hydroxyproline, and the paucity of aromatic residues. Particularly the large amount of hydroxyproline is unique, and also important for the characterization of collagen as a class and for its estimation (Neuman and Logan[18]; van Robertson[28–30]). The great variation of the hydroxyproline content of collagen from various sources, from 6 to 14 per cent, necessitates consideration of the origin of the collagen. Reference may be made to Bear's lucid discussion[31] on the classification of the collagen family. Further, approximately every third amino-acid residue of collagen is generally considered to be a pyrrolidine residue. This proportion is an integral part of recent models of collagen (Astbury[32], Pauling and Corey[33] and Bear[31]). Besides this regular sequence, Pauling and Corey[34] suggest occasional units of one residue of prolines of four residues (seven 1 : 3 and four 1 : 4). The present results show that in some teleost collagens the proportion is scarcely half the number assumed.

The markedly different degree of hydrothermal stability of the skins of the two types of fishes is probably related to the different habitat, and possibly is of biological significance.

The results from investigation of numerous species of fishes show that there is a definite connexion between the hydrothermal stability and the hydroxyproline content of collagen. With decreasing percentages of this residue, the T_s of collagen is lowered, the maximum difference being more than 30 deg. C. (68° and 34°). Obviously, this is no evidence in itself for the view that the hydroxyproline residue is directly involved in the stabilization of the collagen, for example, by forming a site for an interchain hydrogen bond. The effect of the irregularity of the polypeptide chains imposed by the incorporation of the prolines may be indirect, and even fortuitous.

If collagen is mainly stabilized by interchain hydrogen bonds on oppositely located keto-imide groups of adjacent chains, the content of pyrrolidine residues should be a factor of importance. The residues of the prolines which are built into the polypeptide chains with the formation of —CO·N= links introduce a regular interruption of the normal —CO·NH— links, formed by the remainder of the amino-acid residues. Accordingly, sites for the compensation of adjacent —CO-groups of the keto-imide links are withdrawn, which implies fewer stabilizing cross-links and consequently a lowered degree of stability[35]. Then, mammalian collagen should be less stable to heat than fish collagen. However, the reverse is true.

Interchain hydrogen bond between hydroxy and keto-imide groups. On the other hand, supposing that the hydroxy groups of the residues of the hydroxyamino-acids may enter into interchain hydrogen bonding with some other groups, for example, the carboxyl, or the carbonyl of the —CO·NH— linkage, the stability of the structure would be expected to increase with the content of hydroxyproline, as is actually found[3,21].

The effect of the hydroxyproline on the degree of stability and reactivity of collagen was first examined

Table 2. Proline and Hydroxyproline Contents of Collagens

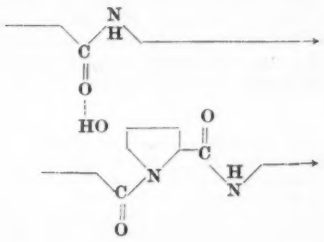
No.	Type of skin	Proline		Hydroxyproline		Proline + hydroxyproline	
		Per cent on protein	Per cent of total nitrogen	Per cent on protein	Per cent of total nitrogen	Per cent on protein	Per cent of total nitrogen
1	Cod fish	10·8	7·2	5·8	3·4	16·6	10·6
2	Pike	13·3	8·8	7·9	4·6	21·2	13·4
3	Bovine (calf)	14·1	9·5	12·7	7·4	26·8	16·9

in the light of Klotz's concept[36–39], according to which the hydroxy groups of the residues of the aliphatic hydroxyamino-acids form strong hydrogen bonds with the carboxyl ions in some globular proteins. This linkage has been shown to affect the reactivity of the carboxyl ion[38]. The reactions of bovine and cod-skin collagen with the simple cupric ion, and with a number of complex chromium compounds, dyestuffs and non-electrolytes, have been studied in the isoelectric range of collagen. The results could not readily be reconciled with an extension of the Klotz concept to collagens. Moreover, according to Bear[31], the electron-optical evidence suggests the presence of the residues of the prolines in the interbands, whereas the bands should contain the residues of the dicarboxylic amino-acids. Hence, the formation of the —OH—O$\overline{C}$O— bond appears improbable sterically.

A satisfactory explanation of the correlation of the hydroxyproline content of collagens and their T_s, and indications of the type of link formed, have been arrived at by investigations of the behaviour of exhaustively acetylated bovine collagen. Such a collagen with all its amino-groups (0·39 m.mol./gm. collagen) and 80 per cent of its hydroxy groups inactivated (1·39 m.mol./gm. collagen) was obtained by acetylating hide powder and calfskin, according to the method of Green *et al.*[40]. Comparative experiments with N-acetylated collagen were included. The hydrothermal stability of collagen is not affected by its N-acetylation, while the N- and O-acetylation, that is, the blocking of the hydroxy- and amino-groups, lowers the T_s from 64–66° C. to 40–44° C.[12]. This finding indicates the rupture of *interchain* cross-links by the O-acetylation.

Assuming that the aliphatic hydroxy groups are preferentially acetylated, at least 0·8 m.mol. of hydroxyproline per gm. collagen should have reacted. Hence, out of 1·07 m.mol. hydroxyproline residues of the original collagen[16], three out of four hydroxy groups have been blocked. In this connexion, it is of interest to note that T_s for the O-acetylated bovine collagen coincides with that of the skins of most cold-water fish, suggesting that the hydroxy group resisting acetylation forms a stronger bond than the rest of the hydroxy groups, and further that this particular group is mainly responsible for the stabilization of the teleost collagen.

From the investigations of the effect of the inactivation of the hydroxy groups of collagen on its reactivity, the results from series with condensed vegetable tannins (mimosa) and non-ionic complexes of sulphito–chromium sulphates are most instructive. The fixation of these compounds by collagen is appreciably increased by its heat-denaturation, and by its pretreatment with lyotropic agents, indicating that the irreversible fixation of these compounds by collagen involves non-ionic protein groups (hydrogen bonding)[4]. The mimosa tannins are mainly fixed by hydrogen bonding of the polyphenolic structures on the carbonyl oxygen of the keto-imide group[41,42]. The very marked affinity of the condensed tannins for modified polyamides, which contain the —CO·NH— linkage as the principal site of binding, is the crucial proof[41]. It is important to note that the non-ionic chromium complexes are not bound by the polyamides[42,43]. Hence, they are probably not reacting with the keto-imide linkage of collagen. Accordingly, the increased fixation of these chromium complexes by heat-denaturation of collagen and by its pretreatment with lyotropic agents (urea, for example) cannot be due to the freeing of co-ordination sites on the —CO·NH— linkages. By O-acetylation of collagen, the irreversible binding of mimosa tannins by collagen is greatly increased, from 60 to 95–105 per cent, on the basis of protein. On the other hand, the fixation of the non-ionic chromium complexes is markedly impaired by the blocking of the hydroxy groups by acetylation, decreases of the order of 30 per cent being commonly found. These findings, with due regard for other facts which cannot be enumerated here, are in harmony with the view that a part of the hydroxy groups is linked by a hydrogen bond to the keto-imide group, schematically, as :



The rupture of such a bond by heat denaturation, or by the lyotropic pretreatments mentioned, should satisfactorily explain both the increased fixation of vegetable tannins (by the freed —CO·NH— bond) and of the non-ionic chromium complexes (by the freed OH— bond), as well as the effects of the blocking of the hydroxy group, that is, the impaired hydroxy-co-ordination of the chromium compounds, on one hand, and the increased binding of the keto-imide-attached polyphenols, on the other. The large decrease of T_s recorded ($\Delta T_s = -22$ deg. C.) is also explained. In view of the marked affinity of the native collagen for the agents mentioned, it is probable that only a few of the hydroxy and keto-imide groups are participating in this interchain cross-linking.

The following considerations suggest that the hydroxy group involved is mainly furnished by the hydroxyproline residue. In the presence of an aliphatic OH group in intermolecular cross-linking, the teleost collagen should form a more stable structure than the bovine type, since the fish collagen contains more such hydroxy groups than the bovine collagen. In view of the reverse trend of the shrinkage temperature, aliphatic hydroxy groups are not likely to be involved to any great extent.

According to Prof. R. S. Bear, of the Massachusetts Institute of Technology, the interchain cross-link suggested can be accommodated in the present helical model of collagen without difficulty[44].

The cross-link common to collagens generally. The strong bond forming the mainstay of the collagen structure, which the masked hydroxy group is indicated to form, is probably an ester bond, the —O·CO— link. The origin of the hydroxy group in this link is not known. Experimental evidence for such a link in procollagen has recently been obtained by Grassmann *et al.*[45]. Further, the insolubility of collagen in saturated lithium bromide solution, which dissolves hydrogen-bonded structures, suggests the presence of some type of a strong bond in collagen (Alexander, personal communication). Moreover,

the increase of the fixation of safranine O by collagen from 0·4 to 0·9 mgm. equiv. per gm. collagen, found by Veis and Cohen[46] on denaturing collagen by heating it in water at 60° for 1 hr., supports this view, as does also the marked difference in alkali binding of limed collagen and gelatin, with due correction for amide groups, possibly due to the splitting of the ester bond in the alkali-processing of gelatin (Gustavson, unpublished results). As to the hydrogen bond suggested, it should be noted that, in Huggins's new collagen helix[47], the computed distance between the hydroxy group of the hydroxyproline residue and the carbonyl oxygen in the next turn of the helix is 2·9 A., indicating OHO hydrogen bonding (intrahelical).

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ANTERIOR-PITUITARY – HYPOTHALAMIC RELATIONS IN THE FERRET

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A WEALTH of observation has firmly established the fact that the anterior lobe of the pituitary gland plays a vital part in the control of growth and reproduction, and also in several metabolic processes which cannot be classified under these two heads. On the other hand, views about the way its various activities are integrated and controlled remain very elementary. They are broadly of two kinds. The first is that any specific activity of the anterior pituitary, at any given moment, is modulated by a feed-back mechanism in which the determining factor is the level of secretion of the peripheral endocrine tissue which the pituitary gland may be stimulating. For example, as its titre in the blood rises, the œstrogen that is secreted by ovarian tissue when stimulated by the anterior-pituitary follicle-stimulating and luteinizing hormones checks the further secretion of FSH. The second kind of explanation is that the hypothalamus directly controls certain anterior pituitary functions. An illustration of this presumed control is the process of ovulation in animals such as the rabbit, which normally ovulate only after the stimulus of mating. The immediate cause of ovulation is the sudden release of luteinizing hormone, and the belief is that the act of mating sets up a train of nervous stimulation which culminates in the firing of certain hypothalamic neurons, and that these, in turn, stimulate the anterior pituitary to discharge luteinizing hormone. It has also been suggested that the hypothalamus, by influencing the discharge of luteinizing hormone, controls the periodicity of the phases of the œstrous cycle in mammals in which ovulation is spontaneous. A further example of this presumed hypothalamic control is the release of adrenocorticotrophic hormone by the anterior pituitary under certain conditions of stress.

Since there is reason for doubting whether the axons of hypothalamic neurons actually innervate the anterior pituitary gland, the view has been advanced—and now has considerable currency—that certain hypothalamic neurons discharge a chemical substance which passes down their axons and diffuses into the primary capillary loops of the pituitary portal vessels, through which it passes into the sinusoids of the anterior lobe. This chemical substance is the presumed proximate stimulus for the specific activation of the secretory cells in the anterior lobe.

This simple hypothesis is primarily based upon clinical and experimental observations which show that changes in, or stimulation of, certain regions of the hypothalamus may affect processes in which the anterior pituitary is definitely concerned (for example, ovulation in the rabbit). But the rest is supposition. In the first place, there is no evidence that under normal conditions the hypothalamus is a specific relay station in the chain of stimulation of the pituitary which begins, say, either with the act of mating or with a condition of stress. Secondly, if the hypothalamus is a relay station, it is not known

which nuclei are involved in the different responses of the pituitary, or by what specific nervous pathways they themselves are activated. Thirdly, no one has isolated or identified the presumed chemotransmitters which activate the anterior pituitary, and which the hypothalamic neurons are supposed to liberate; nor has any thought been given to the question whether the same degree of specificity applies to the assumed hypothalamic secretions as it supposedly does to those of the anterior pituitary. Fourthly, no proof has been given of the passage of chemotransmitters down the pituitary portal vessels. The only experimental 'proof' which has been offered in defence of the hypothesis is that certain processes in which the anterior pituitary is involved no longer occur when the pituitary gland is transplanted from its normal site, or after the pituitary stalk is effectively divided and the pituitary portal vessels have been prevented from regenerating.

The present communication is mainly concerned with the latter question, and with the part played by the pituitary portal vessels. Donovan and Harris[1] have recently described certain experiments from which they conclude that "the hypophysial portal vessels form a necessary part of the pathway of the light-induced œstrous response in the ferret". They base this view on the fact that one of six ferrets which were subjected to "simple stalk section", and eleven of fourteen in which the stalk was divided and a paper plate inserted between its proximal and distal stumps, failed to come into heat when exposed to artificial light during the winter months. In these animals there were "few, if any, vascular connexions between the median eminence and anterior pituitary gland". In those animals which responded to the light, vascular connexions were always present.

The essential argument here is that something failed to happen when certain vessels were few or absent. In its negative quality the evidence is thus similar to other observations which Harris[2] has adduced in support of his views about the function of the pituitary portal vessels. In the present instance, however, Donovan and Harris's experimental findings differ from some we have reported, and they are therefore concerned to find an explanation for the difference. The first point they make is a collateral one, and concerns certain of our findings which show that, while light acting on the retina accelerates œstrus in the normal, but not in the blind ferret, animals blinded in one season tend to come into heat in the years which follow at the same time as do normal controls[4]. Donovan and Harris hold that the experiments from which this conclusion derives are unconvincing, and their contention is that the animals concerned were not blind. They base this view on the fact that no 'anatomical proof' of blindness was given for sixteen animals in which the operative lesions were in the optic chiasma. But they have apparently overlooked the fact that, of the other forty-two animals in the experiment, eight had had their optic nerves, including sheath, and the remaining thirty-four their optic nerves, excluding sheath, divided. Whether the sixteen animals with lesions in the optic chiasma suffered only from form blindness, for which they were tested, there can be no question that the remaining forty-two were blind in the full connotation of the term.

The second point which they make about our work concerns the pituitary portal vessels. They state that our conclusion—that the vessels do not play an essential part in the response—is based only on the fact that two of our stalk-sectioned ferrets which reacted to the light stimulus were found to lack any vascular connexions between the floor of the hypothalamus and the anterior pituitary. This statement is only partly true. Our conclusion is derived from the fact that the response, whether positive or negative, is independent of the presence (or re-establishment) of a direct vascular link after stalk section. Presumably, however, in concentrating on the two particular ferrets to which they refer, Donovan and Harris appreciate what T. E. Huxley[3] put so well in 1863, that "every hypothesis is bound to explain, or, at any rate, not be inconsistent with, the whole of the facts which it professes to account for; . . . One fact with which it is positively inconsistent is worth as much, and as powerful in negativing the hypothesis, as five hundred".

Apart from the question of numbers, Donovan and Harris make three points about these two of our preparations. The first is that our operative approach to the pituitary stalk was not as good as theirs. Whether or not this is true, the point is quite immaterial. What matters is that we have obtained preparations in which the pituitary gland was completely sealed off from direct vascular connexion with the hypothalamus, and in which positive responses to light occurred. Their second point is that it is easier to get a clear picture of the vascular anatomy of the pituitary with sections 100 μ and 200 μ thick than with the thin sections of 10 μ which we have used. And their third, that when they examined the pituitary region of one of the two preparations to which they refer, they found that "a significant proportion of the visible blood vessels did not contain Indian ink". Had Prof. Harris and Mr. Donovan had more time for their examination, they would have seen that these two remarks are incorrect, if by them they mean to imply that 10-μ sections are inadequate to reveal the vascular anatomy of our preparations. Injected vessels are present in every section, and everywhere except where they should be according to the hypothesis that Donovan and Harris are defending. Furthermore, in the preparation in question, a barrier of cellulose (paper) surrounded by reaction tissue completely seals off the median eminence from the anterior lobe, and there is no direct nervous or vascular connexion of any kind between the pituitary on one hand and the base of the brain on the other. This is fully illustrated in the complete account of these experiments[5].

Since the point is of critical importance to the hypothesis which Donovan and Harris are defending, we have made a three-dimensional wax reconstruction of the serial sections of the pituitary region of yet another ferret (reported on for the first time here) which responded to light after the pituitary stalk had been divided and a plate of waxed paper inserted between its proximal and distal stumps. The animal lived for six months after the operation, and the paper became completely surrounded by reaction tissue. The sella turcica containing the pars distalis of the pituitary (the neural process having completely involuted) was roofed over by a massive barrier consisting of a double plate of new bone containing in its interior a mesh of cellulose (Fig. 1). The sections do not reveal any direct vascular connexion between the anterior pituitary and the floor of the brain, but show that the remains of the pituitary portal channels emptied into the vessels of the fibrous reaction tissue on the upper surface of the bone and cellulose barrier. The new bone surrounding

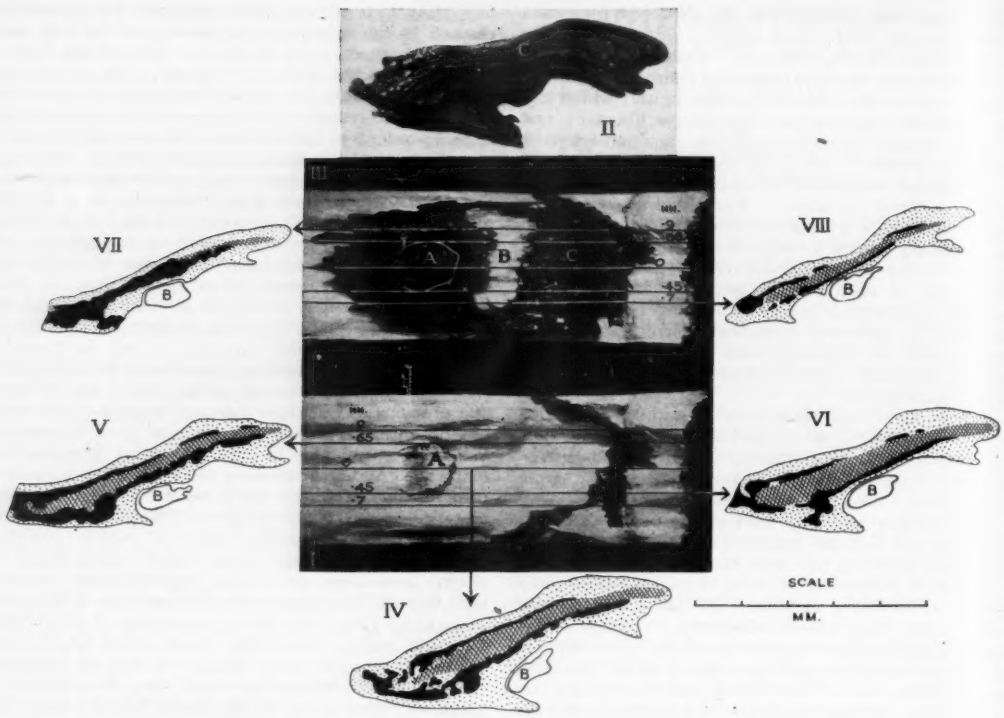

Fig. 1. Wax reconstruction of serial sections of pituitary region in a ferret (*T.F.* 836)

I. Floor of hypothalamus, showing median eminence and remains of proximal stump of pituitary stalk (*A*)
II. Side view of block of reaction tissue (*C*) which separated the pituitary gland (*B*) from the floor of the hypothalamus. It consists of a core of cellulose surrounded by new bone and fibrous tissue
III. Block of reaction tissue (*C*) in position between base of brain and pituitary gland (*B*). The position of the median eminence and proximal stump of the pituitary stalk (*A*) has been projected on to the surface and is outlined in white
IV–VIII. The five lines intersecting I and III mark the sagittal planes, through the block of reaction tissue, that are illustrated in IV–VIII. The position of the anterior pituitary is indicated on each of these figures: stippled area, fibrous tissue; solid black, new bone; cross-hatching, broken-up cellulose; *B*, anterior pituitary

the cellulose extended laterally well beyond the margins of the median eminence, and where bone faded out towards the lateral edges of the barrier, the seal separating the pituitary from the lateral part of the floor of the hypothalamus consisted of dense fibrous tissue over which the dura was intact. Whether any chemotransmitters, if such exist, that may have passed from the floor of the hypothalamus into the reaction tissue finally reached the anterior pituitary through the systemic circulation does not concern the question under dispute—the proposition that the pituitary portal vessels are essential to the response of the ancestrous ferret to light.

The purpose of our experiments has all along been to test Harris's hypothesis by transforming it into the positive question: Is a vascular connexion with the median eminence either (*a*) sufficient, other things being equal, or (*b*) necessary for a positive response to light? And the answer to both questions is no. The proof that a vascular connexion is not sufficient is that in cases where one is present, the response has failed to occur; and more decisive, the proof that it is not necessary is that the response occurs in the complete absence of any direct vascular connexion. For these reasons we hold that Harris's hypothesis is untenable. The fact that our now extensive investigations reveal many more instances of ferrets failing to respond to light after surgical interference in the region of the pituitary stalk than those now reported by Donovan and Harris does not affect the argument. It does, however, call for explanation. We ourselves do not know why animals that have been subjected to an operation in the region of the pituitary stalk so frequently manifest hypofunction of the pituitary, but suspect, as do many workers other than Donovan and Harris, that it may be due to pathological changes in the pituitary following on damage to its blood supply, of which the portal vessels constitute a most important element. Anyone who has experience of operating in so small an area as that which surrounds the pituitary gland in an animal the size of a ferret, and who appreciates how the actual disposition of blood vessels varies from specimen to specimen, will know how difficult it is either to limit or standardize this kind of damage. Nevertheless, our experience shows that it is possible to prepare specimens that provide the necessary conditions for testing the hypothesis of which the pituitary-portal vessels have been a main prop.

Our thanks are due to Mr. W. J. Pardoe for his help in preparing the wax reconstruction.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Observation of Desert Locust Swarms by Radar

THE possibility of detecting flying locusts by radar was examined theoretically some years ago, using the deduction of Ryde[1] that the intensity of a centimetric radar echo from raindrops is proportional to ΣND^6, where N is the number of drops of diameter D per unit volume. Raindrops do not exceed about 6 mm. in diameter; and recorded rainfall intensities indicate that there can rarely be more than ten such drops per cubic metre in the heaviest precipitation. More than half the weight of a locust is water; from considerations of water-content alone, a swarm averaging ten flying locusts per cubic metre, as recorded in the Kenya Highlands in 1945[2], with each locust containing about 1 c.c. of water, might be expected to give an echo of intensity at least an order of magnitude greater than that given by the very heavy precipitation considered; and it was concluded that recognizable echoes might well be given by much more attenuated swarms. Subsequent field-work[3,4] has suggested that considerably lower volume densities, of the order of 0·1 locust per cubic metre, are in fact more representative of even the denser parts of flying swarms; densities of this order, however, might still be expected to give echoes comparable with those given by heavy precipitation.

Radar equipment was known to be in regular use in the determination of upper winds at a series of meteorological stations within the invasion area of the desert locust (*Schistocerca gregaria* Forsk.), and an approach was accordingly made in 1950 to the Meteorological Office, through the Anti-Locust Research Centre. The co-operation of the Air Ministry stations concerned was at once offered by the Meteorological Office, with the comment that, since the back-scattering of the radiated energy is largely a surface phenomenon, results were likely to be somewhat better than would be indicated by considerations of water-content alone. At the same time it was pointed out that a type of radar giving plan-position-indicator form of presentation would be more suitable for observing locusts than the *GL* III equipment in use at the meteorological stations concerned.

The first radar sighting of a locust swarm was in fact recorded at 17.00 G.M.T. (20.15 local time) on March 22, 1954, at lat. 28° 50′ N., long. 49° 30′ E., in the Persian Gulf about midway between Bushire and Kuwait, by H.M.S. *Wild Goose*. A naval centimetric combined air- and surface-warning radar set was used, with a tilted parabolic cheese aerial. The locusts appeared to constitute a swarm of at least 15 miles radius, and were detected at ranges up to sixty miles, over a sector of up to 80°, giving large 'fluffy' echoes on a plan-position-indicator, similar to the effects of mechanical jamming. Flying locusts were seen at the time in the light of a 10-in. signalling projector, and dead ones were seen next morning floating on the sea, at a density estimated at about a thousand locusts over 40,000 sq. yd. This confirmation of the earlier theoretical conclusion opens up possibilities of securing new information on the structure, density and movement of flying swarms which come within range of suitable radar installations, especially from photographic records of the echoes observed; such data are likely to be of particular value in the further development of aircraft methods of attacking flying swarms[5].

The locusts concerned were mature (yellow) desert locusts, and were recorded as moving very slowly southwards. The wind was light and variable at the time, following a spell of moderate north-westerlies over the northern Persian Gulf during March 21 and the morning of March 22 (data provided by Chief Meteorological Officer, Middle East Air Force). The locusts represented in all probability one of a number of mature swarms which had been present since late February in the Kuwait area, about a hundred miles to the west and north-west of the position of the ship report.

The time of the radar sighting was two hours after sunset and three-quarters of an hour before moonrise; and the report is of considerable interest as evidence of flight in swarm formation in darkness and over the sea, when visual reactions might be expected to have been minimal and auditory reactions[6] may well have been involved in maintaining swarm cohesion. The air temperature recorded at the time at the ship was 69° F., which is several degrees lower than has previously been recorded during the night flight of desert locusts on such a scale[6]. Most of the locusts, flying higher than the level of the ship, are, however, likely to have been experiencing temperatures above 69°; radiosonde observations from Bahrein Island recorded temperatures of 80° at 1,600 ft. at 14.30 G.M.T. the same day and 78° at 950 ft. at 02.05 the following morning, respectively 7 deg. and 11 deg. above the corresponding surface temperatures[7]. The establishment of such a temperature inversion over the Persian Gulf is usual during March[8].

The co-operation of the Royal Navy, the Meteorological Office, and the East African Meteorological Department is gratefully acknowledged.

R. C. RAINEY

Desert Locust Survey Headquarters,
Nairobi, Kenya.
Nov. 24.

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Widespread Diurnal Variations of Effective Slope of the Ionosphere

OVER a period of twelve months, measurements have been made at Seagrove Radio Research Station of the bearing and elevation angles of radio signals received from two transmitting stations at about the same distance but in directions differing by almost 90° from the receiving station. From these measurements the effective slopes of the ionosphere have been found to be related at places about 1,500 km. apart, and the average diurnal variation of these slopes has been measured.

The measurements were made on the rotating interferometer situated at Seagrove, Auckland[1], and refer to the horizontally polarized component of the incoming wave. The equipment is such that the observed incoming angle is that of the particular wave which gives the greatest output from the horizontal multiple-loop aerials employed.

The two transmitting stations chosen for this investigation were : *ZQD*, Nandi, Fiji, on 9,315 kc./s., distant 2,000 km. almost magnetically north, and *VLQ*9, Brisbane, Queensland, on 9,660 kc./s., distant 2,250 km. almost magnetically west.

The measured angles were averaged over each hourly period and then over as many days as possible in each month.

Let $\delta(x)$ be the measured elevation angle for station x ; $\Delta(x)$ the elevation angle for station x which would have been measured in the presence of a horizontal ionosphere ; $\theta(x)$ the measured bearing angle for station x ; $\Theta(x)$ the great circle bearing, measured east of north ; $\psi(NS)$, $\psi(EW)$ the effective slopes of the ionosphere about north–south and east–west lines as axes, the slope angle being measured from the horizontal and regarded as positive for an increasing height towards the north or east.

Then, if the angles of arrival may be assumed to occur as the sum of the various ionospheric effects, we have :

$$\begin{aligned} \delta(ZQD) &= \Delta(ZQD) + \psi(EW) \\ \delta(VLQ9) &= \Delta(VLQ9) - \psi(NS) \\ \theta(ZQD) &= \Theta(ZQD) - k.\psi(NS) \\ \theta(VLQ9) &= \Theta(VLQ9) - k.\psi(EW), \end{aligned} \qquad (1)$$

where k is a factor depending on the geometry of the transmission paths.

From the measured angles it has been possible to choose some months during which conditions over the two paths were similar enough for $\Delta(ZQD)$ and $\Delta(VLQ9)$ to be considered identical (except for a small constant factor arising from the small difference in path-length). Under these conditions, it can be seen from equations (1) that a plot of $\{\delta(ZQD) - \delta(VLQ9)\}$ as a function of $\{\theta(ZQD) + \theta(VLQ9)\}$ defines a straight line of slope $-1/k$. In Fig. 1 the experimental results averaged over the months July (1953) and March, April and May (1954) have been plotted in this way. The times shown against the points refer to local time at the mid-point of the path. The points lie on a line of slope $-0{\cdot}5$ during the day-time, but the points for night-time indicate that the assumption of equality of $\Delta(ZQD)$ and $\Delta(VLQ9)$ is not then valid.

Using the experimental value of $k = 0{\cdot}5$, the effective slopes of the ionosphere may be found, since (apart from some constant factors),

$$\begin{aligned} 2\psi(NS) &= \delta(ZQD) - \delta(VLQ9) - \{\theta(ZQD) - \theta(VLQ9)\}/k \\ 2\psi(EW) &= \delta(ZQD) - \delta(VLQ9) + \{\theta(ZQD) - \theta(VLQ9)\}/k \end{aligned} \qquad (2)$$

$\psi(NS)$ and $\psi(EW)$ have been plotted in Fig. 2 from equations 2 using the same experimental results as before. The heavy full and dotted lines show the smoothed day-time behaviour.

The Seagrove Radio Research Station is operated by the Physics Department, Auckland University College, and receives a grant from the New Zealand Department of Scientific and Industrial Research. The work briefly described above is to be published more fully elsewhere.

H. A. Whale

Seagrove Radio Research Station,
Auckland, N.Z.
Aug. 19.

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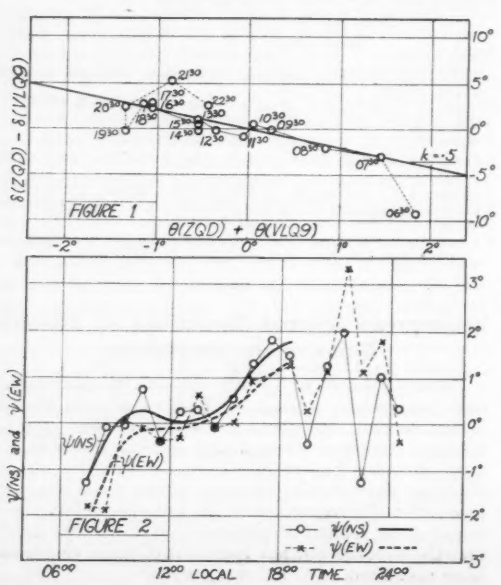


Radio Astronomy in Hawaii

Since early 1953, observations of cosmic static have been made at an altitude of 10,020 ft. from the top of Haleakala volcano on the island of Maui in the Hawaiian archipelago near lat. 20° N. A Lloyd's mirror technique is used with frequencies near 20, 30, 50 and 100 Mc./s. The anomalies introduced by the ionosphere at the first three frequencies are so great that most of the results are unintelligible. At 100 Mc./s. the situation is sufficiently simple to be partly understood. Sources with discontinuities of surface brightness small compared to a minute of arc produce rapid interference patterns. Smooth sources of larger angular width produce much slower diffraction patterns. The hours of darkness provide the best results. During the day, radiations from the sun stir up the topmost parts of the atmosphere far above the *F*-layer. This situation manifests itself as great absorption, probably due to scattering, especially during the afternoon hours. Thus there is a marked diurnal effect. This diurnal effect is least on far northern sources and increases rapidly in magnitude and duration as sources of lower declination are observed. Obviously, there is also an azimuth effect.

During the present part of the solar activity cycle the background intensity of the sun is very constant from day to day and month to month. Also the azimuth of the sun changes with the seasons. When farthest north at the summer solstice, quite acceptable and reproducible diffraction patterns are secured. If a very small bright source is also present, a faint interference pattern may be riding along on top. With the advance of the seasons, the sun moves south and the results depreciate. The faint interference patterns disappear, the diffraction pat-

tern gets weak, sunrise appears late and is not distinct. By the time the autumnal equinox arrives the solar pattern is merely incoherent fluctuations having a period of 3–20 min. with an amplitude less than a tenth that present near the summer solstice. As this is being written, the sun has faded out altogether near the horizon and can only be detected through the high secondary lobes of the antenna. The best explanation of these observations seems to be that there is a great bulge in the outer parts of the earth's atmosphere approximating to a thick disk perhaps 30° or 40° wide. When looking out to the north, one observes through a thin and relatively transparent region. As the source moves farther south, the line of sight has to traverse a longer path through the turbulent scattering region, and less energy arrives in a more incoherent state at the observer. The situation at sunset is similar to that described above, except that the phenomena are more complex due to the presence of well-developed E- and F_1-layers which are usually absent at sunrise. It seems profitable to follow up these observations at other frequencies.

The outstanding sources in Cassiopeia and Cygnus still show interference patterns at 100 Mc./s. Both apparently are of considerable asymmetry because the rising and setting patterns are different. This situation is particularly marked in the case of Cassiopeia, which produces an excellent compound interference pattern on rising but only a diffraction pattern on setting. The details of these studies will be described elsewhere. They are supported by the Research Corporation.

GROTE REBER

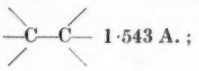
Wailuku, Maui,
Hawaii.
Oct. 12.

Carbon–Carbon and Carbon–Hydrogen Distances in Simple Polyatomic Molecules

A DEPENDENCE of bond distances on environment was first noticed when the carbon–carbon single-bond distance in methyl acetylene was compared with that in ethane[1]. In recent years, a wealth of material based mainly on infra-red and microwave spectra[2] has confirmed this dependence. Still more recently, the study of high-resolution rotational Raman spectra has supplied further data (partly unpublished) on this dependence. It is the purpose of this communication to review briefly the results of the work on carbon–carbon and carbon–hydrogen distances.

A number of compounds have now been investigated in which, similar to methyl acetylene, a carbon–carbon single bond is adjacent to a triple bond. In all these cases, the C—C distance comes out to be close to that originally found for methyl acetylene, namely, $1{\cdot}460 \pm 0{\cdot}003$ A., whereas in ethane and in diamond, where all adjacent bonds are single, the C—C distances are 1·543 A.[3] and 1·54447 A.[4], respectively. The result

for the —C—C≡ distance appears to be largely independent of whether the atom attached to the triple bond is carbon or nitrogen. It was first shown by Pauling, Springall and Palmer[5] by means of electron diffraction that the C—C distances in diacetylene and dicyanogen, with a triple bond on each side of the C—C bond, are even smaller than in methyl acetylene and similar compounds. More precise values have more recently been obtained by Vallance Jones[6], Westenberg and Wilson[7] and Møller and Stoicheff[8]. The average, again independent of whether carbon or nitrogen is attached to the triple bond, is $1{\cdot}380 \pm 0{\cdot}002$ A. Thus we have the series:

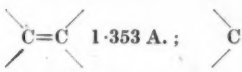


—C—C— 1·543 A.; —C—C≡ 1·460 A.;

≡C—C≡ 1·380 A.

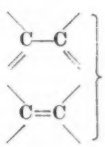
The decrease from the second to the third distance is approximately the same as from the first to the second.

The carbon–carbon double-bond distance in ethylene is well known to be 1·353 A., as shown by Gallaway and Barker[9]. One of us (B. P. S., unpublished) has recently obtained the rotational Raman spectra of light and heavy allene (C_3H_4 and C_3D_4), in which there are two adjacent C=C bonds. The spectra give for the carbon–carbon distance 1·309 A., a value that is appreciably lower than that of a C=C bond surrounded by single bonds only. A similar though less accurate value has been obtained by Johnson and Strandberg[10] for ketene (CH_2CO). Thus we have:



C=C 1·353 A.; C=C= 1·309 A.

Recently, from the rotational Raman spectrum, Stoicheff[11] has obtained a precise value of the carbon–carbon distance in benzene, namely, 1·397 A. This value corresponds to a mixture of a single bond adjacent to two double bonds and a double bond adjacent to single bonds. Unfortunately, the former is not yet known separately. However, we may write:



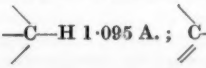
1·397 A.

For comparison, the carbon–carbon triple bond distance is:

—C≡C— 1·207 A.,

a value that is surprisingly independent of the type of atom attached to the single bonds. In particular, in methyl acetylene[12], cyanoacetylene[7], and dimethyl triacetylene[13] (X-ray diffraction), the triple bond maintains its normal length in spite of the fact that the adjacent C—C single bond has apparently borrowed some strength from the triple bonds, that is, is considerably reduced in length. One might have expected that the triple bond in these compounds would be longer than normal.

The carbon–hydrogen distance also depends on the environment, as has been pointed out before[14], but the dependence is not as strong as for the carbon–carbon distances. Using recent data, we have:



—C—H 1·095 A.; C—H 1·07$_1$ A.; ≡C—H 1·065 A.

Of these values, that for ≡C—H is an equilibrium internuclear distance, whereas all other values quoted

here are r_0 values, that is, they include zero-point vibration. The value for $\equiv C-H$ is probably the most accurate, that for $\overset{\diagdown}{\underset{\diagup}{CH}}$ the least accurate. For benzene, which might have been expected to give a value similar to ethylene, Stoicheff[11] found 1·084 A. Slightly different values for the C—H distance in methane are obtained, depending on which isotope is chosen; but they are within a few thousandths of the value given.

Similar differences have been found by several authors[15] for the C—Cl, C—Br, C—I bonds, depending on whether they are adjacent to a triple bond or single bonds. But in these cases, unlike those discussed above, there is also a dependence on the adjacent atoms. A clear case of this kind is the $\overset{\diagdown}{\underset{\diagup}{C}}-F$ bond which, in methyl fluoride[16], has the length 1·385, in fluoroform 1·332 A.[17]. However, in the case of the C—C, C=C, C≡C and C—H bonds, the effect of adjacent atoms on the bond-length seems to be small compared to the effect of the adjacent bond-type.

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Corrosion Fatigue of Low-Alloy Chromium–Molybdenum Steel as affected by the State of Heat Treatment

Manuel has shown[1] that the spheroidized zones which exist on each side of a weld in plain carbon steel are a source of accelerated corrosion in oil-well drilling tubes.

Modern hollow mining-drill steel rods possess such a spheroidized zone near the shank end. The rods are manufactured from as-rolled material, the shank end being austenitized, quenched and tempered. Thus there exists in the rod a short section containing spheroidized carbide, which occurs at the junction of the as-rolled body and the heat-treated shank. This zone can be distinguished by a marked 'valley' in a hardness traverse carried out along the rod, by etching and by micro-examination.

Approximately 95 per cent of mining-drill steel rods in use at Kalgoorlie have the following composition: carbon 0·97 per cent, chromium 1·15 per cent, molybdenum 0·25 per cent, silicon 0·20 per cent, manganese 0·25 per cent.

In a group of fifty fractures of such rods which has been examined here, it was observed that no fracture occurred at the point of lowest hardness (the fully spheroidized section) where fatigue failure would be expected to occur. The fatigue limit of the steel with fully spheroidized carbide was estimated from tensile test results to be 66,500 lb. per sq. in. However, in the case of thirty-seven of the fractures, failure occurred at the point where spheroidization was just beginning, the stepped surface of these failures pointing to corrosion fatigue. The fatigue limit of this structure was estimated from tensile test results to be 107,300 lb. per sq. in. The source of failure in each case was at the central hole.

A ferroxyl accelerated corrosion test was carried out on a scale-free shank containing a spheroidized zone, illustrated in Fig. 1 (above). It was observed that marked accelerated corrosion occurred at the spheroidized zone, as shown in Fig. 1 (below). This zone was thus more anodic than any other point on the surface, the internal hole acting as cathode in this test.

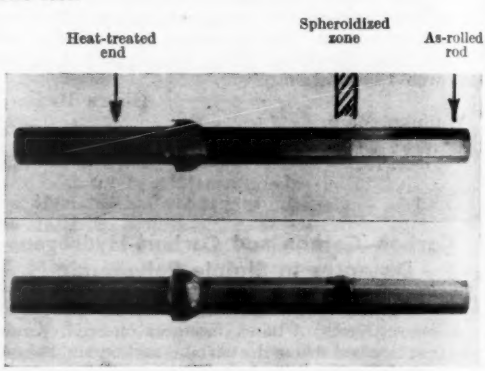

Fig. 1. *Above:* Shank end of drill steel, showing the junction between as-rolled rod and the heat-treated end, at which the spheroidized zone occurs

Below: Same shank as above, after immersion for seven days in ferroxyl reagent. The adhering band is of agar jelly containing the complex ferrous-ferricyanide ion. This band marks the highly anodic region which corresponds to the spheroidized zone above

In practice, accelerated corrosion occurs at the spheroidized zone from the internal hole, the flushing water in this hole acting as electrolyte. The corrosion pits produced then act as stress concentrators, and failure occurs by corrosion fatigue.

Further work is proposed to investigate the effect of heat treatment on the rate of corrosion of steels covering a range of compositions, the tests including loss of weight and electrode potential measurements of samples with various structures.

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A Light Condenser for Spectrographical Purposes

THE luminosity of a transparent light source, such as a fluorescent liquid, can be intensified by the principle of superposition[1]. We have devised an intensifying device for spectrographical purposes applicable directly to a light-emitting tube.

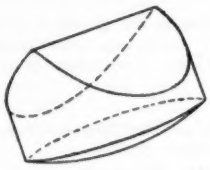

Fig. 1

Two special prisms P_1, P_2, each of which is a combination of a right-angled prism and a convex lens, having an axis of symmetry (Fig. 1), are set at a distance apart from each other, the lens surfaces face to face, with the axes on the same line, and the two edges parallel to each other (Fig. 2). Let the radii of curvature R_1, R_2 of the lens surfaces L_1, L_2, the distance between them l, and the distances d_1, d_2 between the edges and the lens surfaces in the respective prisms, be limited by the following conditions for convenience sake: (1) $R_1 = R_2$; (2) $d_1 = d_2$; (3) the foci on both sides of the lens systems L_1, L_2 fall on the two edges E_1, E_2 of the prisms respectively.

It is most important to make the angle of P_1 exactly 90°, and the angle of P_2 90° − ε, where ε is a very small angle.

Though in practice excitation of light is taking place in the space between L_1 and L_2, to make the explanation easier we assume for the moment a light source on the plane S, which contains E_1 and is perpendicular to the common axis, and is imagined to be in the prism substance. It will be shown later that the imaginary source has an effect equivalent to the actual one in this case. From the light pencil emitted from a point Q on S in the direction of P_2, we take the ray $Q(1)$, which is parallel to the axis, (1) being the point at which the ray falls on the lens surface L_1.

Though the ray $Q(1)$ passes on and goes through E_2, a ray which comes infinitesimally close to $Q(1)$ and on the nearer side to the axis falls first on the total reflecting plane T_2' and then on T_2, and when it comes back again to the surface L_1, it strikes the point (2) which is nearer to the axis by $2\varepsilon d_2 + 2\varepsilon ln$ than (1), where n is the refractive index at L_2. As in the prism P_1 the ray advances parallel to the axis, it falls on S at the point Q', which is also nearer to E_1 by $2\varepsilon d_2 + 2\varepsilon ln$ than Q. Of the light pencil emitted from Q as imagined above, that half which is on the nearer side of $Q(1)$ to the axis (let us call this an inside half-pencil) becomes a parallel beam in P_2, and suffering total reflexion twice, by T_2' and T_2 successively, it returns to P_1 and converges to Q' on S. Thus the image of Q made by the inside half-pencil is Q', which is $2\varepsilon d_2 + 2\varepsilon ln$ nearer to the edge than Q. But actually, before it converges to Q' the pencil returns once more to P_2 by total reflexions at T_1 and T_1', just as it starts from the point Q'', which is symmetrical to Q' with reference to the neutral plane. It will be noticed that the restarting pencil is inside, the converging one to Q' being outside. Now the position is the same as the starting point, and the next image of Q'' is formed on S and $2\varepsilon d_2 + 2\varepsilon ln$ nearer E_1 than Q''.

If we make a narrow plane S_1 perpendicular to the axis, by removing the edge E_1, it is clear that the circulating half-pencil comes at last to intersect this plane S_1, and is superposed here on the direct beam. If in practice excitation of light is taking place in the space between L_1 and L_2, the effective imaginary pencil starting from Q passes perfectly through the emitting space, and we can thus substitute a real pencil for the assumed one within the meaning of geometrical optics. On the other hand, successive images of Q made by the outside half-pencil arrive on S farther and farther from the axis, and we can never collect them.

Next, we calculate the total luminosity I_t given by inside half-pencils at S_1. If we denote the luminosity of the direct beam coming through the window L_1 and S_1 by I, and the rate of intensity loss during one circulation by r, I_t is given by:

$$I_t = 2\{I + (l - r)\,I + (l - r)^2\,I + \ldots\}$$

in which the term number is given in the most favourable case ($2\varepsilon d_2 + 2\varepsilon ln = b$) by $\frac{A}{2}\Big/b$, where A is the aperture of L_1 and b the breadth of S_1. The factor $\frac{A}{2}$ arises from the fact that a pair of symmetrical points on S gives a perfect beam through S_1, and that the actual rays emitted between L_1 and L_2 give, on one hand, a pencil diverging from Q, and on the other, converging to the point.

If we neglect absorption loss, we are only concerned with the reflexion losses at L_1 and L_2. Let us assume $r = 16$ per cent, considering a case of emission from a gas; then

$$I_t = 2I\left\{1 + \frac{84}{100} + \left(\frac{84}{100}\right)^2 + \left(\frac{84}{100}\right)^3 + \ldots\right\}.$$

If we make b sufficiently small compared to A, we can take as an approximation the infinite series, and

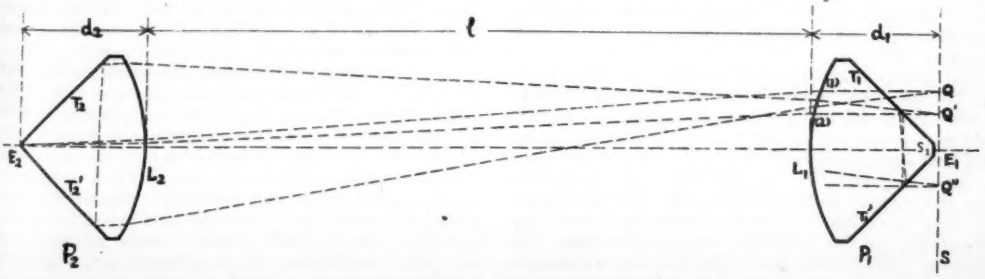

Fig. 2

$$I_t \doteqdot 2I \frac{1}{1 - \frac{84}{100}} = 2 \times \frac{100}{16} I \doteqdot 12I.$$

But when the emitting substance is a liquid, we can generally expect a larger intensification owing to a smaller r. Generally speaking, a high refractive index of the prism substance is required at T_1, T_1', T_2 and T_2' to make the reflexions perfect, whereas at L_1 and L_2 a low value is preferable to make r small. It is very difficult to make the prism angles exactly correct. With our discharge tube, on the ends of which the two special prisms are stuck, ε is somewhat smaller than the value calculated, and the value of I_t was only $7I$.

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Uniform Field Breakdown in Air

Recent work by Llewellyn Jones and Parker[1] on the steady-state current flow in a uniform field gap in air subjected to a steady d.c. potential has been interpreted in terms of the Townsend theory of breakdown involving a secondary or γ-process. Oscillographic observation, however, shows that, as the breakdown voltage is approached, relatively high current pulses of short duration occur. It can be shown that these pulses, both in amplitude and frequency of repetition, do not conform to the Townsend theory, and this suggests that another mechanism is involved.

It can also be shown that, when a high value of series resistor is included in the circuit, it is in theory virtually impossible to reach the Townsend criterion for breakdown. Experimentally, however, no difficulty is experienced in causing a breakdown under these conditions.

The application of stochastic methods to the Townsend theory of breakdown shows that, even if the secondary process is assumed to be the fastest possible, that is, entirely photoelectric in nature, the calculated formative time-lags are longer than those observed experimentally[2] and that the discharge would be diffuse. Experimentally, the discharge is observed to be filamentary.

Further, the velocity of observable luminosity across the gap, on the Townsend theory, is slower than the experimentally observed velocity by a factor of about 10^4.

The above evidence suggests that in addition to the Townsend mechanism, a streamer-like mechanism is also involved in the breakdown of the uniform field gap in air for values of $pd \sim 500$ mm. Hg cm. The best agreement with the available experimental evidence appears to be obtained by postulating that the current build-up due to the Townsend primary and secondary processes provides conditions favourable for the initiation of the streamer. The streamer then moves across the gap and causes the breakdown to be completed. Such a postulate also provides a single theory to explain the breakdown of gaps of different geometry, the geometry deciding the manner in which the critical conditions for streamer initiation are established.

On the above mechanism, it can be shown that the existence of a secondary process is not essential to cause breakdown, and that the failure of some experimenters to detect a secondary process is thereby explained.

A full discussion is being prepared for submission elsewhere. This work was done during my tenure of an I.C.I. research fellowship, which is gratefully acknowledged.

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Preparation of Solid Solutions of Free Radicals at Room Temperature

Organic free radicals can be produced by irradiation with ultra-violet light of molecules held in a transparent rigid medium at low temperatures[1,2]. The method consists in dissolving a suitable substance, D, in a solvent which forms a transparent glass on freezing. The solution is cooled to the temperature of liquid nitrogen and exposed to ultra-violet light. After a time it becomes coloured, and optical absorption spectroscopy shows that free radicals have been created. These radicals persist until the glass is warmed so as to lose its rigidity. Such radicals may be formed in several ways, but the simplest of these is 'photo-oxidation'[1]—the ejection of an electron from the illuminated molecule, D. We restrict ourselves to those substances which form radicals only by this process. It seems that the high viscosity of the glassy solvent prevents the recombination of the resulting radical ion, D^+, and the ejected electron[1].

The use of solutions at the temperature of liquid nitrogen is not always convenient, so we have investigated the possibility of producing free radicals at room temperature. Instead of using a solvent which freezes to a glass, we tried to create free radicals in a medium which is glass-like at room temperatures and which, moreover, can be formed without heating. A solid solution in transparent methyl methacrylate plastic (I.C.I. 'Perspex') was used, and this was illuminated at room temperature. Such a solution was prepared as follows: some N,N′-tetramethyl *p*-phenylenediamine ('Wurster's base', $(CH_3)_2N.C_6H_4.N(CH_3)_2$), which is known to form free radical ions by photo-oxidation, was dissolved in chloroform, and mixed with a liquid solution of 'Perspex', also in chloroform. The fluid was then poured on to a glass plate and the chloroform evaporated, leaving a thin film behind. After illumination at room temperature for 5 min. with ultra-violet light from a high-pressure mercury lamp, the film turned brown. It was shown by means of paramagnetic resonance[2] that free radicals were now present in the film. A sample was made by folding the film into a pellet, and a single paramagnetic resonance absorption line was found, a few gauss in width and with $g = 2{\cdot}001 \pm 0{\cdot}002$, which is typical

of a free radical. The dependence of the resonance absorption on temperature was similar to that of Wurster's radical ion, $(CH_3)_2N.(C_6H_4).N(CH_3)_2^+$, the intensity of the absorption rising to a maximum near 200° K.[4].

Films of pure 'Perspex' showed no paramagnetic resonance after illumination with ultra-violet light.

The experiment was repeated with a solution of *p*-phenylenediamine, $NH_2.C_6H_4.NH_2$, which also forms free radical ions by photo-oxidation, though less easily than Wurster's base. After 25 min. illumination, the film became coloured, brown at the edges and grey-green in the centre. Paramagnetic resonance showed that free radicals were present in the film, the concentration being greater in the grey-green part.

The radicals produced in this manner are rather stable. Paramagnetic resonance of about the original intensity was found after the illuminated film had been kept for a month at room temperature. After ten months, however, paramagnetic resonance could not be detected, although the film remained coloured. It is noteworthy that, though these substances deteriorate in air, a sufficient number of molecules survive the film-making process to give a reasonable yield of free radicals.

The use of a thin film allows the formation of free radicals throughout the sample, even by quanta corresponding to wave-lengths where the absorption of the 'Perspex' becomes appreciable (less than about 3,000 A.). These radiations will, however, be able to pass through such a thin film. Furthermore, a thin transparent film should be convenient for optical measurements, and this technique should be useful for studying free radicals which are normally unstable.

We are indebted to the University of Oxford for the award of a Pressed Steel Co., Ltd., research fellowship (D. B.), and to the Department of Scientific and Industrial Research for a maintenance grant (A. C. R.-I.) during the tenure of which these researches were carried out.

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Solubility of Oxygen in Water

In a recent communication, Truesdale and Downing[1] reported that the values for the solubility of oxygen in de-ionized distilled water, determined by the Winkler[2] method, were significantly lower than the standard values commonly employed[3]. They gave a new empirical equation valid in the range 0–40° C., relating the solubility and the temperature.

In connexion with some investigations on the salting-out of oxygen in aqueous electrolytes, a number of determinations of the solubility of oxygen in distilled water at 25° C. were made over a period of several months. The Winkler method, modified to the extent that 0·01 *N* thiosulphate instead of 0·025 *N* usually recommended was employed and, as in the case of the authors mentioned, air freed from carbon dioxide and saturated with water vapour was used. In the experimental arrangement the air was drawn slowly through the water until equilibrium was established.

The results obtained at 25° C. in five series of determinations gave values, corrected for pressure, in the range 8·07 ± 0·05 p.p.m. The equation of Truesdale and Downing yields at 25° C. a value of 8·11 p.p.m., while the figure quoted in "Standard Methods"[3] is 8·38 p.p.m. The present results are an independent confirmation of the results recently reported and underline the need for a revision of the 'standard' values.

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Oxygen Exchange between Nitrous Acid and Water

The exchange of oxygen atoms between nitrous acid and isotopically enriched water has been followed by the isolation of the nitrous acid as its insoluble silver salt, and the decomposition of this salt, to water, by heating with dry ammonium chloride *in vacuo*. The water produced was then equilibrated with carbon dioxide, and the isotopic content of this gas determined mass spectrometrically.

The work of Hughes, Ingold and Ridd, and Schmid (summarized in ref. 1), showed that under appropriate conditions the active nitrosating agent in diazotization was dinitrogen trioxide, N_2O_3, formed by the reaction:

$$H_2N^+O_2 + NO^-_2 \rightleftharpoons N_2O_3 + H_2O; \qquad (1)$$

but that under somewhat different conditions the reagent was either the nitrous acidium ion, $H_2N^+O_2$, or the nitrosonium ion, N^+O, derived from it.

Any of these entities, or all, could give oxygen exchange between nitrous acid and water, by reaction (1), by the hydration of the nitrosonium ion (2), or by the reaction between water and the nitrous acidium ion (3):

$$N^+O + H_2O \rightleftharpoons H_2N^+O_2 \qquad (2)$$

$$H_2{}^{18}O + H_2N^+O_2 \rightleftharpoons H_2N^+O^{18}O + H_2O \qquad (3)$$

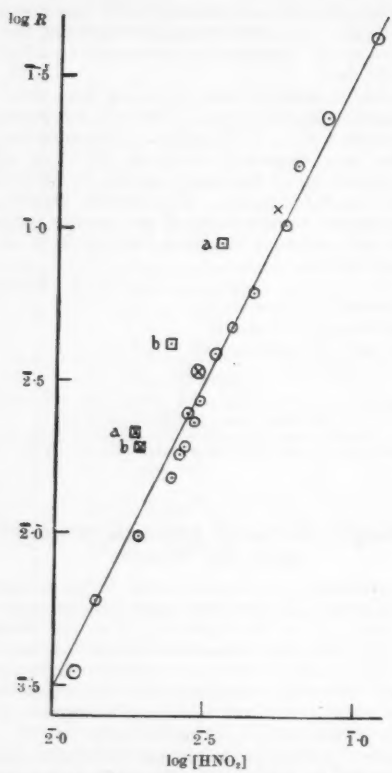
A distinction between some of these mechanisms can be made by following the dependence of exchange-rate on the concentration of nitrous acid. It can readily be shown that exchange by reaction (1) will follow the kinetic law:

$$\text{Rate} = k_2\,[HNO_2]^2,$$

where $[HNO_2]$ is the concentration of molecular nitrous acid; but that reactions (2) and (3) will give:

$$\text{Rate} \propto [H^+]\,[HNO_2].$$

To allow the isolation of sufficient material for our isotopic analysis method, a solution of sodium nitrite (concentration varying between 0·4 and 1 *M*) was used, and to this was added not more than one-fifth the equivalent of perchloric acid. Under these conditions we can assume the concentration of molecular nitrous acid to be given by the stoichiometric



Dependence of exchange-rate on concentration of nitrous acid in absence and presence of other ions. ⊙, no added ions; ⊗, $[NO_3^-]$, 0·529 *M*; ×, $[ClO_4^-]$, 0·445 *M*; ⊡, $[Cl^-]$, (*a*) 2·36 *M*; (*b*) 2·31 *M*; ⊠, $[Br^-]$, (*a*) 1·265 *M*; (*b*) 1·067 *M*

concentration of perchloric acid, after correcting for the initial decomposition of the nitrous acid.

The relation between exchange-rate and concentration of nitrous acid is plotted logarithmically in Fig. 1, and the straight line is drawn with a slope of 2. This clearly shows the dependence of exchange-rate on $[HNO_2]^2$, and the results do not fit the kinetic forms of reactions (2) and (3). We are able to show that under our conditions the addition of even high concentrations (*c.* 0·5 *M*) of sodium perchlorate and nitrate have no very marked effect on the exchange, but that the halide ions Cl^- and Br^- enhance the rate of exchange, presumably by the reaction:

$$H_2N^+O_2 + X^- \rightleftharpoons NO - X + H_2O$$

(where X = Cl, Br), a reaction which is known to play a part in the halide ion catalysis of diazotization[1].

It is instructive to compare the values which we observe for k_2, the second-order rate coefficient for oxygen exchange with respect to HNO_2, with the second-order rate coefficient for diazotization under conditions in which the rate is independent of amine concentration. The value of k_2 for oxygen exchange is 32 mol. l.$^{-1}$ min.$^{-1}$, and that for diazotization (private communication, Hughes, Ingold and Ridd) is 40 mol. l.$^{-1}$ min.$^{-1}$ (this latter value is somewhat dependent upon the value taken for the dissociation constant of the nitrous acid, whereas the corresponding rate-coefficient for oxygen exchange is independent of this constant); we have calculated the diazotization-rate using the value of $3·2 \times 10^{-4}$ mol. l.$^{-1}$, at 0°, for the dissociation constant[2]. The agreement between these rates is reasonably close, particularly in view of the widely differing reagent concentrations used (the diazotization experiments were carried out with reagent concentration *c.* 10^{-3} *M*; private communication, Hughes, Ingold and Ridd).

If we assume an exchange mechanism, under our experimental conditions, involving attack of nitrite ion on the nitrous acidium ion, we can use the data of the halide ion catalysis to calculate the reactivities of chloride and bromide ions, relative to nitrite ion taken as unity, towards the nitrous acidium ion: the values are: Cl^-, 0·38; Br^-, 0·46. The value for bromide ion is, as expected, greater than for chloride[1], and is comparable with the value of 0·54 obtained by the measurement of bromide-ion catalysis of diazotization (Hughes, Ingold and Ridd, private communication). In the exchange measurements no correction has been made for any ionic strength effect caused by the added halide ions.

It is probable that at higher acid concentrations the nitrite ion concentration will be reduced sufficiently to allow exchange by reactions (2) and (3), with a consequent change of kinetic form.

We are indebted to Profs. E. D. Hughes and C. K. Ingold, and to Dr. J. H. Ridd, for their advice and for their prior communication of their diazotization results.

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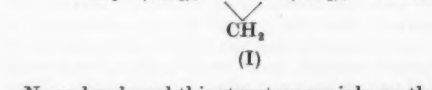
Structure of Sterculic Acid

The structure of sterculic acid, the major component of the kernel oil of *Sterculia foetida*, has attracted the attention of various workers. Hilditch *et al.*[1] failed to isolate the acid but concluded from the constants of the oil and the mixed methyl esters and some degradative experiments that it was 12-methyl octadeca-9 : 11-dienoic acid. Steger and Van Loon[2], working on the mixed fatty acids, deduced that it was probably a hydroxy acid, $C_{18}H_{34}O_3$. However, recently Nunn[3] has isolated this acid, $C_{19}H_{34}O_2$, by the method of urea complexes and suggested its structure as ω-(2*n*-octyl*cyclo*prop-1-enyl)-octanoic acid (I).



(I)

Nunn has based this structure mainly on the strong band at 9·8 μ in the infra-red spectrum of dihydrosterculic acid. He has, however, not taken the infra-red curve of the sterculic acid itself, and the position of the double bond seems to have been fixed without any supporting evidence.

In this laboratory, sterculic acid has been separated from the mixed fatty acids by low-temperature fractional crystallization in the colourless crystalline form, $C_{19}H_{34}O_2$ (m.p. 19°, n_D^{25} 1·4758). Its catalytic hydrogenation gives dihydro- and tetrahydro-sterculic

acids, suggesting the presence of two, or the equivalent of two, double bonds.

From the iodine value (98·2) and diene value (40·3), it may be inferred that these double bonds are probably conjugated, although the ultra-violet absorption spectrum does not show any band in the region 2200–3200 A. The infra-red curve, however, gives clear indication of a *cyclo*propane ring at 9·96 μ and a double bond (C = C) at 6·09 μ on the shoulder of the strong carbonyl band at 5·9 μ.

The *cyclo*propane ring exhibits typical unsaturation towards many specific additive reagents, as demonstrated by Kohler and Conant[4]. Therefore, the *cyclo*propane ring in sterculic acid may form a 'conjugated system' with the double bond, resulting in structure (II).

$$CH_3-(CH_2)_6-CH\underset{CH_2}{\diagdown\diagup}CH-CH=CH-(CH_2)_7-COOH$$

(II)

Reduction and oxidation products obtained by various investigators[1,3] and also by us find ready explanation with this structure.

Further, the synthesis of compound I has been effected from stearolic acid by the action of diazomethane. This synthetic product gives an infra-red curve which is different from that of sterculic acid, thereby conclusively showing that the structure (I) is not correct.

The details of this work will be published elsewhere.

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Separation of Saponins by Paper Chromatography

In the course of a study on the composition of saponins from Indian raw materials, difficulties were encountered in the complete separation of the glycosides in pure form by chemical means. The usual method of repeated precipitation with solvents is not dependable and does not ensure the chemical purity of the separated products, the more so because many of the saponins are hygroscopic.

A convenient method of separation has now been developed by paper partition chromatography. The spray reagent used was sodium periodate in alkaline permanganate solution, recently reported by Lemieux and Bauer[1] for the detection of carbohydrates; this has been found to be satisfactory in the case of saponins, giving permanent brown spots against a white background.

Qualitative characterization of the fairly pure saponins[2], isolated in this laboratory, was carried out on Whatman No. 1 filter-paper by the ascending method[3] with the system *n*-butanol – acetic acid – water (4 : 1 : 5) for 10–24 hr., and the dried papers were sprayed with a freshly prepared solution of sodium meta-periodate in alkaline potassium permanganate solution. The papers were left for an appropriate time (5–6 min.) before they were washed with running water, when distinct brown spots of saponins appeared against the almost white background of the paper. On drying, these spots remained unchanged for an indefinite period.

Table 1

Saponins isolated from	No. of saponins isolated by chemical method	No. of saponins as shown by chromatography	R_F values
Entada scandens (Gila)	2	2	(1) 0·246 (2) 0·386
Balanites roxburghii (Hingora)	1	1	0·202
Balanites roxburghii pericarp	1	2	(1) 0·215 (2) 0·312
Balanites roxburghii kernel	1	1	0·222
Sapindus trifoliatus (Ritha)	1	1*	0·203
Bassia latifolia (Mahua)			

* One distinct spot and two indistinct spots on the strip

The R_F values found for the respective saponins are shown in Table 1. By employing this method, it has been possible to show that the saponins, purified by the usual chemical procedure, are in some cases actually composed of more than one saponin. Other solvent systems are being examined. Details will be published elsewhere in due course.

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Techniques for labelling Trees with Radioactive Phosphorus

Insects feeding on plants in nutrient culture solution have been labelled with tracer-levels of radioactive isotopes in studies of insect feeding-habits[1] and insecticidal action[2]. Such insects have also been released in the field for population studies[3], and others fed on labelled artificial diets have been used in the study of insect metabolism[4].

To investigate the movement of the mealybug vectors of swollen shoot disease of cacao, techniques were studied for obtaining radioactive trees for the subsequent labelling of insects at their feeding sites under field conditions. The artificial release of labelled insects in the field is unsatisfactory for such investigations.

By the first method a panel of bark was removed from the stem of *Abutilon* sp. and 1·5 mc. of phosphorus-32 in a volume of 3 ml. held in a 'Plasticine' cup was introduced laterally through the severed conducting vessels. After 24 hr., leaves 4 ft. above the area of introduction provided 300 counts/min./sq. cm., and after 48 hr. nymphs of *Dysdercus* sp. feeding 5 ft. above the place of injection provided 12–346 counts/min. This technique has been used successfully in translocation studies with dyes[5], and the resulting mechanical damage to the tree is small. The amount of radiophosphorus translocated is uncertain because of the high residual activity on the 'Plasticine' cup. With high levels of activity, this technique presents some radiation hazard in the field. Fig. 1 shows that

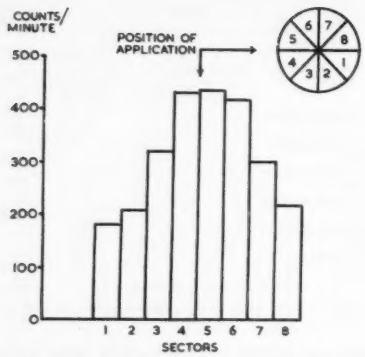

Fig. 1. Activity distribution on the cross-section of the trunk of *Abutilon* sp. 1 ft. above the position of application

fourteen days after application the activity remained localized on that side of the stem at which the radiophosphorus was introduced.

In the second method, 5 mc. of phosphorus-32 in 10 ml. of solution was introduced through a glass tube sealed with 'Picine' wax into a small hole at the base of a young *Syringa vulgaris* L. Fig. 2 shows the activities recorded from 1·5 cm. leaf disks cut on the main veins of opposite leaves 4 ft. above the point of introduction and 24 hr. after uptake of the active solution. The distribution of activity within the tree was very localized, but adult mealybugs (*Planococcus citri* (Risso)) fed for seven days on young shoots gave counts of 13–42/min. This technique produces little mechanical damage to the tree, but minor leakages are difficult to eliminate. The efficiency of this technique may undoubtedly be improved by the methods employed for diagnosing mineral deficiencies[6,7].

By a third method, 1 mc. in 0·7 ml. and 9 mc. in 1·5 ml. of solution of phosphorus-32 was introduced into two Douglas firs (*Pseudotsuga taxifolia* (Poir.) Britt.) by trunk implantation. Such techniques have

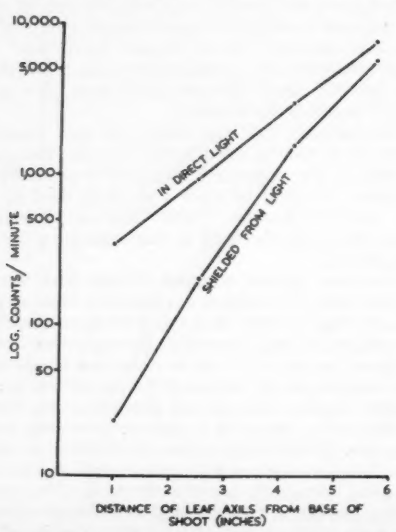

Fig. 2. Activities from 1·5 cm. diameter leaf disks cut on the main veins of opposite leaves of a young shoot of *Syringa vulgaris* L. 24 hr. after the introduction of 5 mc. of phosphorus-32

Table 1. Counts per sec. recorded on the Cut Ends of the Trunks of *Pseudotsuga taxifolia* (Poir.) Britt. implanted with 1 mc. and 9 mc. of Phosphorus-32

Height above ground (ft.)	Dose			
	9 mc.		1 mc.	
	Trunk diameter (in.)	counts/sec.	Trunk diameter (in.)	counts/sec.
4	3·3	300	3·7	80
6	3·1	500	3·5	4
8	3·0	350	3·5	12
10	2·9	150	3·5	50
12	2·8	100	3·5	20
14	2·5	200	3·0 2·0	30 ≏ Bg.
16	2·0	80	3·0 1·5 1·5	18 ≏ Bg. ≏ Bg.
18	1·8	90	1·8 2·1	7 ≏ Bg.
20	1·4	100	1·5 2·0	5 ≏ Bg.
22	1·0	60		
24	0·6	7		
26	0·4	2		

≏ Bg. = counts approximating to background-level (3 counts/sec.).

Table 2. Counts per sec. recorded on the Trunk Surface of *Pseudotsuga taxifolia* (Poir.) Britt. implanted with 9 mc. of Phosphorus-32

Height above ground (ft.)	Surface			
	Front	Left	Back	Right
3	≏ ∞ position of implantation	> 2,000	80	> 2,000
5	7	≏ Bg.	≏ Bg.	70
7	10	≏ Bg.	≏ Bg.	70
9	≏ Bg.	≏ Bg.	≏ Bg.	400
11	11	≏ Bg.	≏ Bg.	400
13	3	≏ Bg.	7	170
15	5	1	40	140
17	3	12	100	120
19	7	60	110	90
21	7	50	90	50
23	12	50	60	40
25	5	2	2	4
Growing tip, ≏ Bg.		Tips of lateral branches, 0–80.		

≏ Bg. = counts approximating to background-level (3 counts/sec.).

been used in studies with systemic insecticides[8]. Thin glass ampoules containing the active solutions were inserted into 1-in. holes in the trunks and were then broken within the trees by knocking in tight-fitting wooden plugs. Eight days after implantation, total activities were recorded on the cut ends of 2-ft. lengths of trunk at various elevations (Table 1). Activities were also recorded on the trunk surface of the tree implanted with 9 mc. (Table 2); this was not possible with the tree implanted with 1 mc., but 15 counts/sec. were recorded at the tips of lateral branches at about 15 ft. above the ground.

In both trees it was estimated that about 95 per cent of the activity remained at the position of implantation. Table 1 indicates the localization of activity at certain levels and in certain branches of the main trunk. Table 2 indicates a marked localization on one side of the trunk, particularly so at the 9–11 ft. level, at which region there is a decrease in total activity recorded on the cut ends. It is evident, therefore, that at this level the path of translocation approaches the surface of the trunk and that higher measurements result from a decrease in absorption thickness of the wood.

The trees appeared normally healthy at the time of felling. This technique reduces radiation hazard in the field to a minimum. The sizes of hole and ampoule do not permit the use of large volumes of active solution or phosphate carrier which might

assist in translocation from the position of implantation.

The methods described are suitable for obtaining radioactive host plants of insect populations in the field. All three techniques suffer from two disadvantages, namely, the translocation of phosphorus-32 from the point of application is small and the distribution of tracer within the tree is localized. Similar results were obtained with calcium-45 and rubidium-86 injected into yellow birch[9]. Future investigations will be directed towards methods of root application and the use of carriers to aid in tracer distribution. Autoradiography will be used to elucidate the pattern of distribution within the conducting tissues.

These experiments were initiated when I was at the Isotope School, Atomic Energy Research Establishment, Harwell, and I wish to thank Mr. R. A. Faires, of the School, for much valuable advice and help; also Dr. Leyton, at the Forestry Department, Oxford, and Dr. Scott Russell, Department of Agriculture, University of Oxford, for their interest in the work. This communication is published with the consent of the Director of the West African Cacao Research Institute, Gold Coast.

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Acceleration of Citrate Oxidation in Yeast by Aspartic Acid

Citrate oxidation in cell-free extracts of *Saccharomyces cerevisiae* has previously been reported to be stimulated by a weakly basic factor present in boiled yeast juice[1]. It was afterwards observed that ammonia accelerates citrate oxidation when added to the assay system for oxidation factor, and significant amounts of free ammonia were found in the boiled juice prepared from the D.C.L. commercial bakers' yeast investigated[2]. In a further study of different strains of yeast, high oxidation factor activity has now been observed in ammonia-free extracts of Anheuser–Busch commercial bakers' yeast when added to a particulate-free enzyme from the same organism. In these preparations all activity is due to free L-aspartic acid, present in a concentration of 4·6 μM/gm. yeast. The end-product of citrate oxidation in the presence of aspartic acid is glutamic acid. The reaction requires the addition of di- or tri-pyridine nucleotide coenzymes. This is illustrated in Fig. 1.

Excess coenzyme does not inhibit the increased citrate oxidation in the presence of aspartate (aspartate reaction). This clearly distinguishes the effect of aspartate in yeast from the effect in certain mammalian systems where aspartate can be shown to

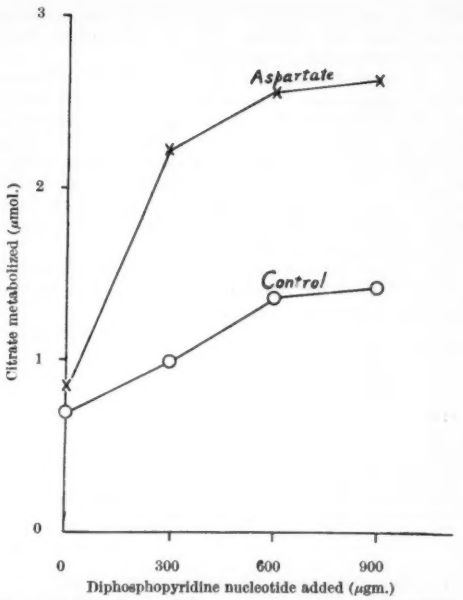

Fig. 1. Dependence of the aspartate reaction on coenzyme. Tube contents: 4 μM citrate, 50 μgm. magnesium, 0·3 ml. enzyme dialysed 24 hr. against 0·1 M potassium phosphate, pH 7·1, at 0° C.; final vol. 1·0 ml. Incubation, 30 min. at 37° C. 2 μM L-aspartate added as indicated. In the presence of excess dipyridine nucleotide, 0·4 μM glutamate was formed in the control, and 2·2 μM in the presence of aspartate

accelerate citrate oxidation by increasing the turnover of reduced coenzyme.

The yeast enzyme actively catalyses the transamination reaction:

$$\text{Aspartate} + \alpha\text{-oxoglutarate} \rightleftharpoons \text{oxalacetate} + \text{glutamate} \quad (1)$$

Any α-oxoglutarate formed from citrate in the presence of aspartate would react to form glutamic acid. This reaction, however, cannot explain the stimulation of citrate oxidation by aspartate, as the breakdown of citrate to α-oxoglutarate is irreversible in the present system. Nor do either aspartate or α-oxoglutarate affect any of the following enzymes involved in citrate oxidation: aconitase, the *iso*citric dehydrogenases specific for di- and tri-pyridine nucleotide, and oxalosuccinic carboxylase. The latter enzyme in all respects resembles the enzyme from pigeon breast muscle studied by Ochoa and Weisz-Tabori[3].

Further evidence against the participation of reaction (1) in the aspartate reaction is presented in Table 1.

Table 1. Conditions as for Fig. 1. L-Glutamate (20 μM), Oxalacetate (5 μM) added as Indicated

Additions	Citrate metabolized (μM)
—	1·47
Aspartate	2·73
Glutamate	1·33
Glutamate and aspartate	2·57
Oxalacetate	1·08
Oxalacetate and glutamate	3·07
Oxalacetate and aspartate	1·08

An excess of glutamic acid sufficient to prevent reaction (1) from proceeding to the right has no appreciable effect on the aspartate reaction. Glutamate + oxalacetate simulate the effect of aspartate, presumably by giving rise to aspartate. The strong

inhibitory action of oxalacetate would be expected on the basis of reaction (1) or any other transamination reaction of aspartate.

In agreement with previous results[4], the aspartate reaction, like other transaminations, is inhibited by high concentrations of cyanide. Pyridoxal phosphate causes no stimulation. The nature of the transamination involved in the aspartate reaction remains unknown. Ammonia, which activates citrate oxidation in both the D.C.L. and the Anheuser–Busch strains of yeast, probably acts by a mechanism similar to the aspartate reaction.

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Distribution of Adrenaline and Noradrenaline in the Adrenal Medulla

In previous papers[1], I have described two histochemically different types of chromaffin cells in the adrenal medulla of the rat. Adrenal medullas of several species have now been studied using the same histochemical methods, and adrenaline and noradrenaline determinations made[2]. The presence of brightly fluorescing cell groups against a dark background of non-fluorescing medullary cells was a constant finding in formalin-fixed sections of the adrenals of most species. Table 1 shows the proportions covered by fluorescing islets and the percentage amounts of noradrenaline in adrenal medullas of different species. Good correlation between the islet content and the noradrenaline content is obvious.

Table 1

Species	Noradrenaline content (% of both catechols)	Fluorescing tissue (% of whole medulla)
Cat	35–60	*c.* 50
Dog	20–40	*c.* 40
Hamster	25–40	*c.* 30
Mouse	15–35	*c.* 25
Rat	10–20	*c.* 15
Guinea pig	5	+?
Rabbit	3	0

In order to study the effect of adreno-medullary stimulation, male rats were injected subcutaneously with insulin (0·6 I.U./100 gm. body-weight at 9 a.m., the same dose at 12 o'clock ; killed at 4 p.m.), or with nicotine (*c.* 1 mgm./100 gm. body-weight ; killed ½–24 hr. later). Chronic overdosage of nicotine was caused by injecting 2–4 mgm. of nicotine daily for about 6½ months ; these rats were killed about two weeks after the last injection. The results are summarized in Fig. 1, which shows that insulin causes a selective depletion of adrenaline and disappearance of the chromaffin reaction from all but some medullary cells, which form islets closely similar to the fluorescing islets. The fluorescence of these islets was not affected by insulin. After a single injection of nicotine, on the contrary, a selective loss of noradrenaline and

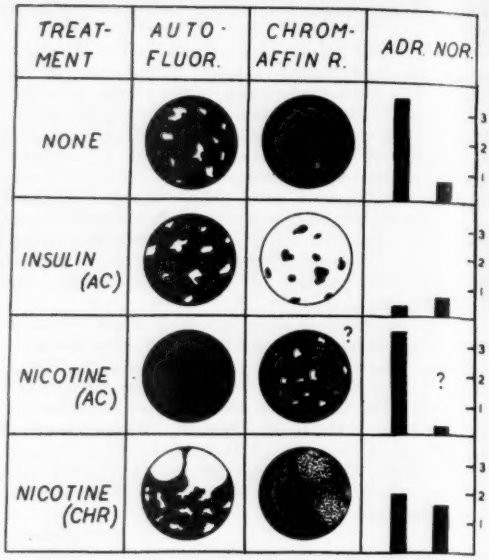

Fig. 1. Schematic illustration of the effects of insulin and nicotine on the histochemistry and catechol amine content of rat adrenal medulla. Distribution of fluorescing substances in the formalin-fixed sections is indicated in white ; chromaffin materials are shown as black. The heights of the columns on the right refer to adrenaline and noradrenaline concentrations, expressed as per cent of dry medullary tissue. *AC* = acute ; *CHR* = chronic

disappearance of fluorescing and chromaffin materials from the 'islet' cells were observed. However, the response was somewhat variable. Prolonged treatment with nicotine caused a medullary hyperplasia associated with a pronounced increase in the relative amount of fluorescing medullary tissue and in the noradrenaline content. All these observations suggest that the two kinds of medullary cells bear specific relations to the storage and secretion of the two kinds of adreno-medullary hormones, a view already put forward in the earlier papers[1].

The problem was investigated more directly in the cat and the hamster. Serial sections were prepared of fresh-frozen glands. Every other section was fixed in formalin and examined for the distribution of the fluorescing islets, and the alternate sections were freeze-dried. Information obtained from neighbouring formalin-fixed sections was used to dissect small pieces of the freeze-dried sections with variable proportions of fluorescing tissue. A piece with much fluorescing tissue always contained a higher proportion of noradrenaline than a piece with little islet tissue, taken from the same section. Small amounts of noradrenaline were nevertheless regularly found in pieces supposed to contain no fluorescing cells. The fluorescing islets were too small to allow mechanical separation of pieces containing exclusively fluorescing cells. Pieces with *c.* 70 per cent of islet tissue were found to contain approximately the same proportion of noradrenaline.

The observations indicate that some adreno-medullary cells contain much adrenaline and little noradrenaline, whereas other cells—which can be demonstrated by fluorescence microscopy of formalin-fixed sections—contain predominantly or exclusively noradrenaline. The fact that noradrenaline forms a strongly fluorescing, poorly water-soluble substance with formalin, which adrenaline does not, suggests

that formalin fixation is a kind of histochemical method for the selective demonstration of noradrenaline in the adrenal medulla, a point now under more detailed study.

While this work was in progress, Hillarp and Hökfelt[3] described a technique for histochemical demonstration of noradrenaline. With this technique, using buffered potassium iodate, they also came to the conclusion that the two medullary catechol amines are stored in two different kinds of cells.

I am grateful to Prof. J. H. Gaddum and to Dr. Marthe Vogt for their guidance and laboratory facilities during the academic year 1952–53, which I spent in the Department of Pharmacology, University of Edinburgh.

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Cyanide-resistant Mitochondria from the Spadix of an *Arum*

Highly active preparations of mitochondria have been obtained from the spadix of *Arum maculatum*[1]. These exhibited the ability to oxidize acids of the Krebs's cycle and pyruvic acid in their presence. No carrier needed to be added and the terminal oxidase responsible for the oxidations was not identified. The respiration of slices of spadix is not inhibited by cyanide[2], even though it is very rapid, with Q_{O_2} rising to 31·8. As mitochondria are generally supposed to promote respiratory oxidations through their contained cytochromes, the reaction of these aroid mitochondria to cyanide is of obvious interest.

Using the method of Hackett and Simon, we were able to prepare mitochondrial suspensions of high activity. The extraction and suspension medium contained 0·05 *M* phosphate buffer, *p*H 7·1; 0·2 *M* sucrose; and 0·001 *M* magnesium sulphate; before oxygen uptake was measured, 0·0004 *M* adenosine triphosphate was added. Endogenous respiration in this medium was virtually nil in all preparations. Addition of citrate, α-ketoglutarate or succinate at 0·02 *M* concentration caused rapid uptake of oxygen. 0·002 *M* Pyruvate in the presence of 0·002 *M* malate was also oxidized.

After two hours incubation at 20° C. the contents of the manometer flasks containing no substrate and with α-ketoglutarate added were examined for acid formation by paper chromatography. 1-ml. aliquots from each were deproteinized with 2 volumes of ethanol, and the dried supernatants, after acidifying with hydrochloric acid, were extracted with six lots of 10 ml. of ether. The ether extracts were run on two-dimensional chromatograms using ethanol-ammonia and mesityl oxide – formic acid as solvents[3]. After spraying the dried papers with bromo-phenol blue, no acids could be detected in the control experiment; but large amounts of citrate, malate, succinate and fumarate had been formed during the incubation with α-ketoglutarate, as shown in Fig. 1. All the α-ketoglutarate added had been oxidized.

Table 1. 1 ml. Mitochondrial Suspension = 2 gm. Fresh Weight of Tissue. Total Volume, 30 ml. T = 20° C.

Substrate	Oxygen uptake (μl.) in 15 min.	Hydrogen cyanide added
Nil	0	—
Citrate	150	151
α-Ketoglutarate	293	(291)
Succinate	388	365
Pyruvate + malate	115	—

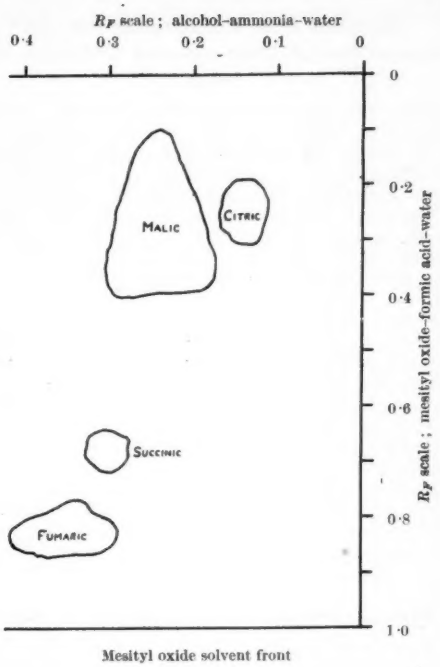

Fig. 1

Addition of 0·001 *M* hydrogen cyanide with the substrate caused no inhibition of oxygen uptake in the presence of citrate or succinate during the first 15 min. There was no inhibition in the presence of α-ketoglutarate, and the pattern of acid formation was not changed either; but here the cyanide would probably be removed as cyanhydrin of the keto-acid present in large excess.

After longer periods partial inhibition slowly developed in the presence of succinate. After two hours it amounted to about 60 per cent; but by this time the rate in the control sample had itself fallen away considerably. In the presence of citrate no inhibition or slowing down had appeared after 55 min.

These experiments appear to confirm the suggestion that the mitochondria of *Arum* spadix are able to catalyse a Krebs's cycle of reactions; but they also indicate that at least some of the oxidations on which it is based are not inhibited by 0·001 *M* cyanide. The partial inhibition that develops slowly in the presence of succinate is very different from the rapid and complete inhibition of the usual metallic oxidases.

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Chelated Iron Compounds for the Correction of Lime-induced Chlorosis in Fruit

Lime-induced chlorosis of fruit trees is a serious problem on calcareous soils in Great Britain, and until recently the only practical means of correcting this disorder was a combination of grass cover and trunk injection of iron salts. The injection method is laborious, transient in effect and often causes severe damage to the trunk, especially to *Prunus* species. Soil treatment with iron salts has not been effective owing to precipitation of iron in the soil.

A new approach to the problem followed the discovery by Jacobson[1] in 1950 that ferric dipotassium ethylenediamine-tetraacetate (Fe-EDTA) was a satisfactory source of iron for plants growing in culture solutions at high *p*H. In 1952 Stewart and Leonard[2] showed that 10–20 gm. of chelated iron per tree (as ferric dipotassium ethylenediamine-tetraacetate) would control iron chlorosis (copper-induced) of citrus trees growing in acid soils. Under alkaline conditions, as much as 100–300 gm. of chelated iron per tree was necessary to control lime-induced chlorosis[3]. The authors considered that such large amounts might render the method impracticable for field use.

Recently, two new chelating agents for trivalent iron have been described by Chaberek and Bersworth[4]. They are N,N′-dihydroxyethylethylenediamine-diacetic acid (HEEDDA) and N-hydroxyethylethylenediamine-triacetic acid (HEEDTA). The iron chelates of these two acids, together with that of diethylenetriamine-pentaacetic acid (DTPA), have been shown by Wallace *et al.*[5] to be more effective in correcting lime-induced chlorosis of ornamental trees than ferric dipotassium ethylenediamine-tetraacetate.

In 1953 small-scale field-trials were started by us to test the effect of ferric disodium ethylenediamine-tetraacetate, as soil dressings and foliage sprays, on lime-induced chlorosis in red currants, plums and pears. Rates of soil dressings were based on the early work of Stewart and Leonard (*loc. cit.*) for citrus in acid soils. These rates proved ineffective under the alkaline soil conditions. The foliage sprays showed promise and no damage occurred on plum and red currant at concentrations of 0·1 per cent or less. An account of these preliminary trials has been given by Bould[6].

Further experiments were made in 1954 on pear and plum growing in a highly calcareous soil of *p*H 7·8, using increased rates of application of ferric disodium ethylenediamine-tetraacetate as a soil dressing, and also varying rates of ferric diethylenetriamine-pentaacetate and ferric N-hydroxyethylethylenediamine-triacetate. For pear the chelates were applied in solution around the trees (within a circle of 6 ft. diameter) and thoroughly watered in. Soil treatments and foliage sprays were also applied to chlorotic plum trees, var. Burbank's Giant Prune. The ferric-ethylenediamine-tetraacetate was broadcast on April 6 around the trees, within a circle of 12 ft. diameter, at the rate of 16 oz. per tree (average height 12 ft. and girth 12 in.) and lightly watered in; the ferric N-hydroxyethylethylenediamine-triacetate was applied in a similar manner at 12 oz. and 16 oz. per tree.

Foliage sprays of both these salts and also of ferric diethylenetriamine-pentaacetate, at 0·1 per cent concentration plus a wetting agent, were applied to plums on three successive occasions: at petal-fall and after two fortnightly intervals.

At another centre one foliage spray of ferric diethylenetriamine-pentaacetate, at 0·1 per cent concentration plus a wetting agent, was applied to extremely chlorotic peach trees on June 29.

The treatments, rates of application, and effects on chlorosis and extension growth of pear are summarized in Table 1. Ferric disodium ethylenediamine-tetraacetate and ferric diethylenetriamine-pentaacetate at 8 oz. per tree gave a complete control of chlorosis and resulted in vigorous extension growth. This is the first recorded response by fruit trees in Great Britain to soil treatments. There was no observable response to the ferric N-hydroxyethylethylenediamine-triacetate, but it should be pointed out that the dressings of this compound supplied much less chelated iron than the other two, and further tests are needed.

The plum trees did not respond to the soil treatments. This may have been due to the failure of the iron chelates to penetrate to the plum roots. The chelates were not thoroughly watered in as for pear, and a dry period followed application.

The foliage sprays on plum gave a commercial control of chlorosis, and, with the exception of ferric disodium ethylenediamine-tetraacetate which produced a little marginal and tip scorch, caused no damage.

Table 1. Effect of Soil Dressings of Chelated Iron on the Incidence of Lime-induced Chlorosis in Pear *var.* Conference on Quince Rootstock

Soil treatment	Amount of chelated iron (gm.)	Date applied	Tree height (ft.)	Tree girth (in.)	Chlorosis 11–8–54	Extension growth 11–8–54
8 oz. Fe-EDTA per tree	32·0	6–4–54	5½	7½	Nil	Very good
12 oz. Fe-EDTA per tree	48·0	6–4–54	5	7	Nil	Very good
4 oz. Fe-HEEDTA per tree (absorbed on vermiculite)	3·4	6–4–54	4½	7½	Severe with necrosis	Poor–medium
6 oz. Fe-HEEDTA per tree	5·1	6–4–54	4	5½	Very severe with necrosis	Poor–medium
8 oz. Fe-HEEDTA per tree	6·8	6–4–54	4½	5	Medium–severe	Medium
Controls	—	—	—	—	Very severe with necrosis	Poor–medium
4 oz. Fe-DTPA per tree	11·4	11–5–54	5	5½	Slight	Medium
6 oz. Fe-DTPA per tree	17·1	11–5–54	4½	5	Trace	Good
8 oz. Fe-DTPA per tree	22·8	11–5–54	6	7	Nil	Very good
Controls	—	—	—	—	Very severe	Poor
45 ml. Fe-HEEDTA per tree (liquid)	1·6	2–6–54	5	5½	Very severe with necrosis	Very poor
75 ml. Fe-HEEDTA per tree	2·6	2–6–54	5½	5½	Medium severe	Poor
150 ml. Fe-HEEDTA per tree	5·3	2–6–54	6	5½	Severe	Poor
200 ml. Fe-HEEDTA per tree	7·0	2–6–54	6	5½	Medium severe	Good
Controls	—	—	—	—	Very severe	Very poor

Three weeks after applying a single foliage spray of ferric diethylenetriamine-pentaacetate to peach trees, the chlorosis had almost completely disappeared and the leaves have remained green until the present date.

These results indicate that control of lime-induced iron chlorosis in fruit trees is possible by soil treatment, providing sufficient iron chelate is used and it is transported to the absorbing roots by rain or heavy watering. The cost of adequate soil dressings of chelates may prove uneconomic on a commercial scale for certain fruit crops. For plums and peaches the foliage spray method appears to give a satisfactory control of chlorosis, during the season of application, at a much lower cost. Pear leaves are more difficult to wet and they are damaged more easily than plum, apple and peach.

The full results of these and of further experiments will be reported elsewhere.

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Sept. 14.

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[2] Stewart, I., and Leonard, C. D., *Citrus Mag.*, **14**, 22 (1952).
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[5] Wallace, A., North, C. P., Kofranek, A. M., and Lunt, O. R., *Calif. Agric.*, **6**, 13 (1953).
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Acarine Disease of the Honeybee and Temperature

It has been suggested from time to time that there may be relationships between acarine disease of honeybees and weather or other environmental factors; but such a view has also often received strongly reasoned opposition, as by Phillips[1] and Morgenthaler[2], and no reliable relationship with a weather factor has so far been forthcoming.

I have now found that if the areas between January isotherms for 27° F. and 54° F. actual temperatures in the northern hemisphere are shaded, upon a map of the world, and areas between July isotherms for 51° F. and 66° F. are shaded the other way upon the map, the two sets of shadings are found in superposition in Britain and adjacent parts of Europe, and the doubly shaded areas correspond fairly closely with the main areas in Europe in which acarine disease is found. Over the rest of the world (using the corresponding July and January isotherms respectively in the southern hemisphere) such overlap occurs only in a few limited areas. One of these areas is in Argentina, in which country acarine disease has been found. In North America—reported to have no acarine disease—there is no overlap except in a very limited area on the extreme west. Asia, in most areas substantially without acarine disease, and Africa and Australia, from which the disease has not been reported, show only very small localized areas of overlap.

The theory is advanced that acarine disease is found only where overlap of these two temperature bands occurs, and that the areas where the two bands cross most centrally (as in Britain) are the areas of highest infestation. New Zealand shows marked overlap, particularly in the south, and on this theory could harbour acarine disease if it were introduced, though so far the disease has not been reported from that country.

It is suggested that the action of high summer temperature in reducing the disease incidence is probably based on the faster working and shorter life-span of the worker bees which obtains under the more favourable foraging conditions, and which gives the mite less time to reach maturity and migrate from bee to bee; the low summer limit apparently coincides rather closely with the temperature limit for effective survival of the honeybee colony itself. The action of low winter temperature in reducing the incidence of disease may be partly due to the disturbed state of a diseased winter cluster, rendering it less able to survive the severe conditions of a cold winter; while the high winter limit may be principally a reflexion of the relatively high summer temperature which, for physical reasons, in temperate zones, apparently almost always accompanies it.

Many significant direct correlations between acarine incidence and temperature have been obtained in the course of this work; for example, a coefficient of $-0{\cdot}50$ (50 degrees of freedom, $P < 0{\cdot}001$) for acarine disease and summer temperature in fifty-two counties in England and Wales on data by Butler[3], and a coefficient of $+ 0{\cdot}51$ (20 degrees of freedom, $P < 0{\cdot}02$) for acarine disease and winter temperature for twenty-two years on data for Britain by Morison[4]; as well as highly significant correlations between incidence of acarine disease and January–July temperature-range, on either Butler's or Morison's data taken separately, and also between acarine disease and suitably selected phenological criteria on either of the above sets of data. It has been found that the above correlations with summer and winter temperatures can be drawn together mathematically into a single working hypothesis, which in operation corresponds closely with the overlap of the isotherm ranges suggested above.

Calculations based on this hypothesis, using temperatures prevailing in Britain in the appropriate years, agree with the timing of the severe epidemic of acarine disease in Britain between about 1904 and 1919, as well as the reduction in its incidence (evident in Morison's data) at the present time. They are also in agreement with the higher incidence of acarine disease in Scotland than in England (also seen in Morison's data) and, when calculations are based on temperatures in Switzerland, with the much lower incidence in that country (Morgenthaler[5]). The calculations show that at the temperatures of the major areas of North America, Africa and Australia, as well as most of Asia, the disease, on this hypothesis, would be unable to maintain itself.

I wish to thank Principal M. A. H. Tincker and Dr. G. D. Morison, of this College, for encouragement, Dr. F. H. C. Marriott, of the University of Aberdeen, for statistical advice, and Dr. C. B. Williams, of the Entomological Department, Rothamsted Experimental Station, for constructive criticism. Further details of this work will be published in due course.

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Sept. 10.

[1] Phillips, E. F., U.S. Dept. Agr. Circ., **218**, 7 (1922).
[2] Morgenthaler, O., *Z. angew. Ent.*, **19**, 459 (1932).
[3] Butler, C. G., *Ann. App. Biol.*, **32**, 344 (1945).
[4] Morison, G. D., Jeffree, E. P., Murray, L., and Allen, M. D. (awaiting publication).
[5] Morgenthaler, O., *Beih. Schweiz. Bienenztg.*, **1**, 285 (1944).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, January 10

ASSOCIATION OF CLINICAL BIOCHEMISTS, SOUTHERN REGION (at University College Hospital, Gower Street, London, W.C.1), at 3.15 p.m.—Annual General Meeting; 4.30 p.m.—Scientific Papers.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Atmospheric Pollution".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.45 p.m.—Sir Geoffrey Vickers, V.C.: "Some Meanings of Progress" (Wilde Memorial Lecture).

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. F. Ehrmann: "Trends in the German Chemical Industry Since the War".

ROYAL GEOGRAPHICAL SOCIETY (joint meeting with the ALPINE CLUB, at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Prof. Ardito Desio: "Ascent of K.2" (Dickson Asia Lecture).

Tuesday, January 11

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. J. C. Fidler: "Volatiles"; Mr. R. A. K. Long: "Some Thermodynamic Properties of Fish and their Effect on the Rate of Freezing".

ILLUMINATING ENGINEERING SOCIETY (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. B. S. Cooper: "Fading and Related Effects Associated with the Radiation from Light Sources".

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. D. Cleverdon, Mr. L. Harvey, Mr. P. G. Smith and Mrs. D. Laker: "Measurement of Molecular Weight by the Light Scattering Method". (Paper will be read by Dr. Cleverdon.)

Wednesday, January 12

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (joint meeting with the SOCIETY FOR APPLIED BACTERIOLOGY, at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1), at 2.15 p.m.—Meeting on "Aeration in Industrial Fermentations".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. T. Neville George: "Carboniferous Main Limestone of the East Crop in South Wales"; Mr. T. N. Clifford: "The Stratigraphy and Structure of Part of the Kintail District of Southern Ross-shire; its Relation to the Northern Highlands".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. E. G. Rowe, Mr. P. Welch and Mr. W. W. Wright: "Thermionic Valves of Improved Quality for Government and Industrial Purposes".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Prof. C. Tyler: "The Chemical, Physical and Structural Characteristics of Egg Shells".

Thursday, January 13

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (in the Science Museum Lecture Theatre, Exhibition Road, London, S.W.7), at 4.30 p.m.—Mr. W. A. Levick: "The Petrochemicals Low Temperature Gas Separation Column".

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. W. F. Cartwright: "Integration in the Iron and Steel Industry".*

Friday, January 14

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Dr. H. S. Turner: "The Synthesis of Radiochemically Labelled Fine Chemicals".

Saturday, January 15

BIOCHEMICAL SOCIETY (in the Physiology and Biochemistry Department, King's College, Strand, London, W.C.2), at 2 p.m.—Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (with a degree in chemistry or physics or the N.D.D.T.) IN THE TECHNICAL CHEMISTRY DEPARTMENT, for work on the manufacture and analysis of milk powders and evaporated milk—The Secretary, Hannah Dairy Research Institute, Kirkhill, Ayr (January 15).

JUNIOR ASSISTANT CHEMISTS (with a B.Sc. degree or equivalent, and preferably with some experience in fuel technology) in the Central Laboratories, South-Eastern Gas Board, 709 Old Kent Road, London, S.E.15—The Personnel Manager, South-Eastern Gas Board, Katharine Street, Croydon, quoting V.28/488 (January 15).

LECTURER IN THEORETICAL PHYSICS—The Registrar, The University, Reading (January 17).

LECTURER/SENIOR LECTURER (preferably interested in undertaking genecological or cytogenetic studies on the Australian flora) IN BOTANY, at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Australia, January 19).

SCIENTIFIC OFFICER, Grade I (with a university degree of high standard in physics or equivalent qualifications, and preferably some experience in optical instrumentation) in the Department of Supply, High-Speed Aerodynamics Division, Aeronautical Research Laboratories (Instrumentation Section), Salisbury, South Australia, for the development and design of general physical and particularly optical instruments for aerodynamics research—The Senior Representative (A.P. 23), Department of Supply, Australia House, Strand, London, W.C.2 (January 20).

PHYSICIST (with a good honours degree in physics or equivalent professional qualifications, and preferably with some experience in research and field experiments), at the Central Research Establishment, Isleworth, Middlesex, to carry out research on strata studies—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/900 (January 22).

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (with G.C.E. advanced level in two scientific subjects or equivalent, and ability to write clear, concise English, and preferably with some knowledge of European languages) in the Department of Scientific and Industrial Research Food Investigation Headquarters, Cambridge, for editorial duties on a journal of scientific and technical abstracts and reviews on food science and technology—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.444/54A (January 22).

EXPERIMENTAL OFFICER (with a knowledge of organic chemistry or biochemistry) IN THE DEPARTMENT OF INSECTICIDES AND FUNGICIDES, to assist in the study of the mode of action of insecticides—The Secretary Rothamsted Experimental Station, Harpenden, Herts (January 22).

LECTURER (with a good honours degree in mechanical engineering or equivalent qualification, and practical experience in industry and in teaching) IN MECHANICAL ENGINEERING—The Principal, Wigan and District Mining and Technical College, Wigan (January 24).

ORGANIC CHEMIST (with an honours degree in science with organic chemistry as a major subject, and some postgraduate research experience) IN THE DIVISION OF FOOD PRESERVATION AND TRANSPORT, Commonwealth Scientific and Industrial Research Organization, Homebush, N.S.W., Australia, for investigations, with a small group of chemists, on chemical reactions occurring on processed foodstuffs during storage and on the chemical composition of the natural products—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 300/151 (January 29).

RESEARCH OFFICER (chemist) (with an honours degree in chemistry, and preferably with research experience in the field of organic chemistry) IN THE BIOCHEMISTRY UNIT, Wool Textile Research Laboratories, Commonwealth Scientific and Industrial Research Organization, Melbourne, to develop specific reagents for the chemical modification of proteins and to study the effect of such reagents on the chemical and physical properties of wool keratin—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 462/76 (January 29).

RESEARCH OFFICERS or SENIOR RESEARCH OFFICERS IN THE COAL RESEARCH SECTION, Commonwealth Scientific and Industrial Research Organization, Sydney, Australia, for (*a*) to undertake investigations of the chemical structure of Australian coals and assessment of their potential value to the chemical industry and, in particular, to examine the behaviour of coals in various chemical reactions such as hydrogenolysis or to study the chemical reactions occurring during the pyrolysis of coals (Ref. 480/150); (*b*) to participate in the activities of a group concerned with the studying of the mechanical properties of coal and their industrial significance (Ref. 480/153); and (*c*) to participate in studies being undertaken to evaluate combustion characteristics of Australian coals (Ref. 480/154)—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2 (January 29).

ENTOMOLOGIST IN THE DEPARTMENT OF ENTOMOLOGY of the Waite Agricultural Research Institute—The Registrar, The University, Adelaide, South Australia (January 31).

PROFESSOR OF EDUCATION at McGill University, Canada—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (January 31).

RESEARCH SCHOLAR IN THE DEPARTMENT OF CHEMISTRY—The Secretary, The University, Aberdeen (January 31).

SCIENTIFIC OFFICER, CHEMIST (with a first- or second-class honours degree in chemistry or in a biological subject with chemistry as an additional subject, or equivalent qualification), at the Brown Trout Research Laboratory, Pitlochry, to be a member of a small team investigating chemical problems of freshwaters, working in close association with Biologists—The Establishment Officer, Scottish Home Department, Room 364, St. Andrew's House, Edinburgh 1 (January 31).

SENIOR LECTURER IN ZOOLOGY at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, January 31).

SENIOR LECTURER IN ENGINEERING, a LECTURER IN PHYSICS, and a LECTURER IN BOTANY, at Fourah Bay College, Sierra Leone—The Secretary, Advisory Committee on Colonial Colleges, 1 Gordon Square, London, W.C.1 (February 7).

LECTURER (Grade II) IN PHYSICS, and a RESEARCH FELLOW IN PHYSICS—The Registrar, The University, Birmingham 15 (February 15).

LECTURER IN EDUCATION at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Hong Kong, February 15).

LECTURER or ASSISTANT LECTURER (with special interests in genetics or genecology) IN BOTANY—The Registrar, The University, Leeds 2 (February 19).